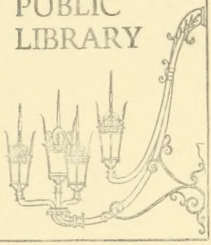
GOVDOC
BRA
1555
vol. 2

BOSTON
PUBLIC
LIBRARY



Government
Documents
BRA
1555
Vol. 2 ✓
A, B, C

VOLUME II

SCHEMATIC DESIGN SUBMISSION

BOSTON
PUBLIC
LIBRARY

PARCEL 7

BOSTON MASSACHUSETTS

· AUGUST 1986 ·

DEVELOPER
CONGRESS 7 LIMITED PARTNERSHIP
ARCHITECT
HELLMUTH, OBATA & KASSABAUM, P.C.

VOLUME II

CONTENTS

1. ENVIRONMENTAL IMPACT STUDY

   A. TRAFFIC IMPACT STUDY AND ACCESS PLAN

   B. WIND TUNNEL TEST REPORT

   C. SHADOW IMPACT ANALYSIS

ENVIRONMENTAL IMPACT STUDY

ENVIRONMENTAL IMPACT STUDY
INTRODUCTION

In accordance with the Boston Redevelopment Authority's (BRA) requirement, an environmental assessment report is made part of the Schematic Design Submission (Volume II).

As specified by the BRA, this report is limited to the traffic, wind and shadow impact of the Parcel 7 mixed-use project on its neighborhood.

A separate Environmental Impact Report (EIR) required by the Massachusetts Environmental Protection Act (MEPA) will also be submitted to the BRA.

1. The traffic impact study and access plan analyzes transportation in the area of the project versus a no build scenario. All parking is underground as per guidelines provided by the BRA. Office building and hotel transportation is addressed, as well as service docks and curb cuts.

2. Wind tunnel tests were conducted as per BRA requirements. Wind testing with and without the project was done for 43 points on and surrounding the site. Amelioration studies were done in order to reduce wind speeds to acceptable levels. Video tape of the wind tunnel testing is also available.

3. Shadow studies based on BRA requirements for dates and time were performed and documented. Existing and new net shadows are shown. It is concluded that new net shadows have no significant impact on the neighborhood.

TRANSPORTATION

TRAFFIC IMPACT STUDY AND ACCESS PLAN

PARCEL 7 DEVELOPMENT
BOSTON, MASSACHUSETTS

July, 1986

prepared for

Congress 7 Limited Partnership
Boston, Massachusetts

prepared by

Vanasse/Hangen
60 Birmingham Parkway
Boston, Massachusetts

INTRODUCTION

This report discusses the transportation impacts of the development project proposed for the Parcel 7 site in Downtown Boston. It also identifies an Access Plan which will help to alleviate existing and future traffic conditions in the area. The report has been prepared for submission to and use by the City of Boston in conformance with a Scope of Work approved by the Boston Redevelopment Authority and the Boston Transportation Department.

The Parcel 7 Development Proposal

The proposed development will consist of approximately 405,000 square feet of hotel, office and retail uses to be completed by the year 1989. Parking will be provided for on-site uses and will be located below grade. The project is designed to work well with the nearby Haymarket pushcart facilities and will be very well served by public transportation. Pedestrian enhancements in the form of covered arcades will also be provided. Table 1 summarizes the anticipated development usage.

TABLE 1
ANTICIPATED DEVELOPMENT USAGE
(SQUARE FEET)

Type of Use	1989
Hotel (381 rooms)	275,000
Office	120,000
Retail	10,000
Total	405,000
Parking Spaces	400

The proposed site is currently an unpaved lot that provides permit parking for City of Boston employees.

Study Area

The transportation study area and analysis intersections were established in consultation with personnel of the Massachusetts Executive Office of Environmental Affairs, MEPA Unit, as well as with the Boston Redevelopment Authority (BRA) and the Boston Transportation Department (BTD). The area is bounded by New Chardon Street, Blackstone Street, North Street and New Congress Street. In addition, the Sudbury Street intersection with Cambridge Street is included. Figure 1 shows the project site in relation to Downtown Boston. The street system includes two-way flow on North and New Congress Streets, and one-way operation on Sudbury Street (eastbound), New Chardon Street (westbound) and Blackstone Street (southbound). Haymarket Station, serving the MBTA Orange and Green Lines, is located just north of the site, although actual station access is provided on the site itself.

Study Methodology

The transportation study was conducted in three distinct phases. Phase I involved inventorying the existing travel demand characteristics in the area. The inventory included researching previous transportation reports as well as conducting new observations of area travel demands. Observations of traffic and pedestrian volumes were conducted at several locations (shown in Figure 2) during the morning and evening peak hours. Adjacent roadway volumes were recorded over 24-hour periods. Some of the counts were made in 1984 during an earlier analysis of Parcel 7. Others were made in 1986 at new locations or to validate the earlier counts.

Data collected during the inventory period were assembled and used to define the existing transportation network as a base condition for subsequent analysis. As required by the Massachusetts Executive Office of Environmental Affairs, MEPA Unit, in its original scoping memorandum for this project, data were collected on a Friday to represent a worst case condition when local pushcart operators have an established right to set up their stands along Blackstone Street (west of the median island only) and a portion of Hanover Street on Friday and Saturday. In addition, pushcarts often set up on North Street at Blackstone Street. This activity results in Hanover Street being blocked and a loss of

Figure 1

Site Location Map

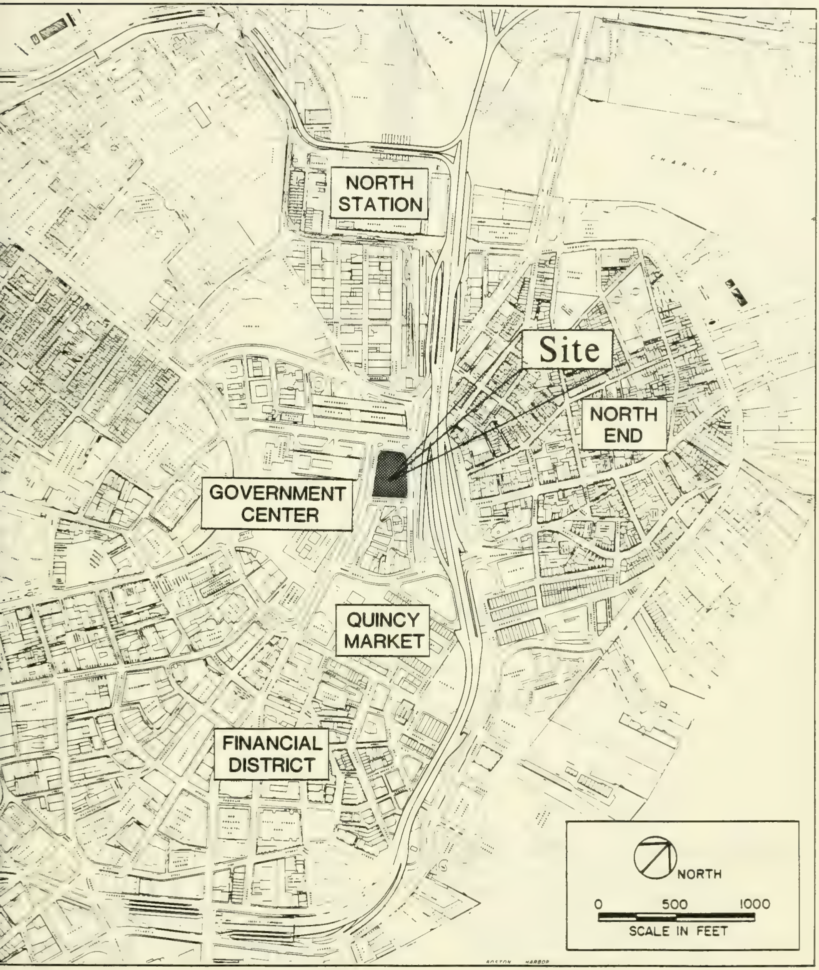
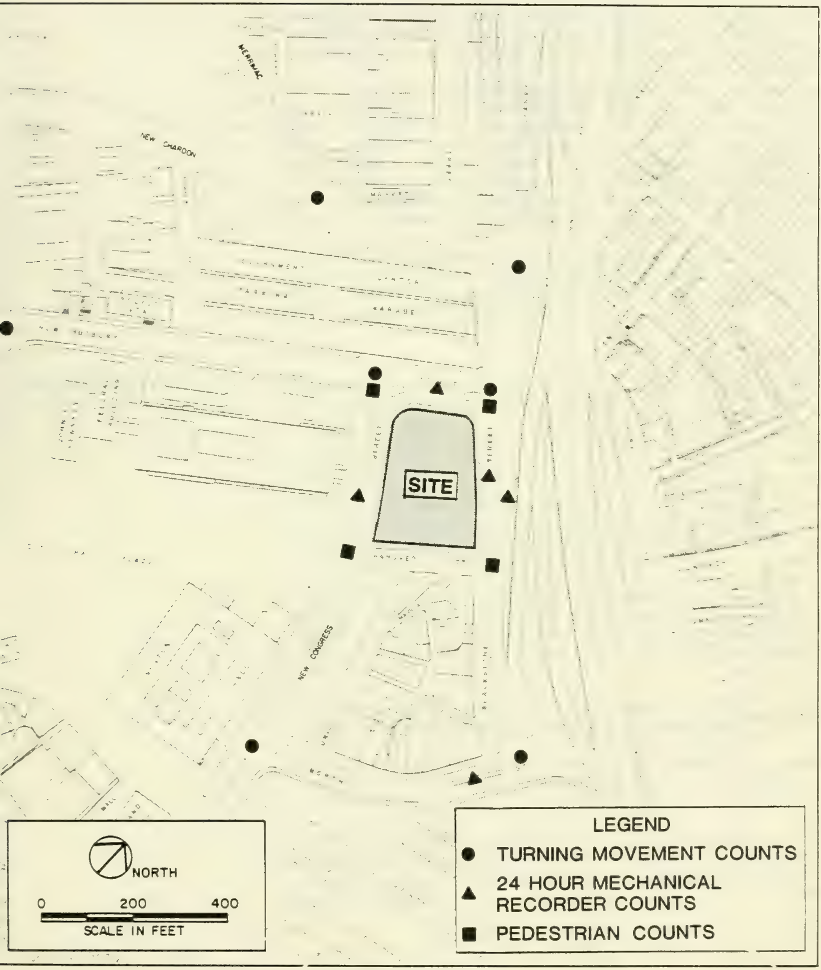


Figure 2 Traffic Survey Locations


MERRIMAC
NEW CHARDON
GOVERNMENT CENTER PARKING GARAGE
SITE
NEW CONGRESS
NORTH
0
200
400
SCALE IN FEET
LEGEND
● TURNING MOVEMENT COUNTS
▲ 24 HOUR MECHANICAL RECORDER COUNTS
■ PEDESTRIAN COUNTS

travel lanes on Blackstone Street east of the median due to delivery vehicles, which significantly restricts local circulation and capacity of the roadway system.

Phase II of the study built upon the data base in Phase I and established the framework for evaluating the transportation impacts of the proposed project. In this phase, specific travel demands of the Parcel 7 development proposal were assessed along with demands created by other future area developments. Estimates were made for all transportation modes; however, emphasis was placed on traffic and parking demands.

The final study phase included evaluation of the impacts of the project on the transportation system, identification of potential measures to mitigate adverse impacts, and development of an Access Plan.

DESCRIPTION OF THE ENVIRONMENT

The roadways within the study area consist of both local and arterial streets, and a limited access highway.

Street System

Access/Circulation/Traffic Control

The street system within the study area provides both regional and local access from all directions.

- The Central Artery, with exit ramps to New Chardon Street and to North Street, provides a link from the north and west. Access from the south is circuitous, with the only exit ramp located on Causeway Street at North Station.
- The Sumner and Callahan Tunnels provide access between the site and East Boston/Logan Airport.
- Hanover Street and North Street provide local circulation in addition to access from the North End Community.
- Blackstone Street provides local circulation and a link from North Washington Street and the Charlestown Bridge to provide access from Charlestown and other points north.

- New Congress Street is part of the local circulation system and also provides access through the Financial District to the Central Artery and points south.
- Sudbury and New Chardon Streets form a one-way pair to provide access to and from Cambridge Street with connections to the west via the Longfellow Bridge and to the south via Tremont Street.

The local street system consists of one-way and two-way streets that result in a generally clockwise circulation around the project site. Figure 3 shows the area circulation pattern.

All major intersections in the area are controlled by traffic signals which are part of the City's system of coordinated signals in the Downtown area. Locations with signal control devices are shown in Figure 3.

Existing Traffic Volumes

Existing daily traffic, AM peak hour (8:00-9:00) traffic and PM peak peak hour (4:30-5:30) traffic are illustrated in Figures 4, 5 and 6, respectively. Table 2 shows daily as well as AM and PM peak hour traffic volumes for Sudbury Street, Blackstone Street, North Street and New Congress Street. The daily traffic volumes range from 5,000 vehicles on North Street (westbound) to 19,000 vehicles on Sudbury Street (eastbound). The AM peak hour traffic in the study area ranges from three to six percent of the daily traffic, while the PM peak hour shows a range of four to nine percent of the daily traffic.

Public Transportation System

The proposed project is well served by public transportation. Figure 7 illustrates the major components of the system in the vicinity of the project and their distances from the site.

Rapid Transit

Direct access to three of the rapid transit lines is within 1,000 feet of the site. The nearest station is Haymarket with access to both the Orange and Green Lines

Figure 3

Study Area Circulation

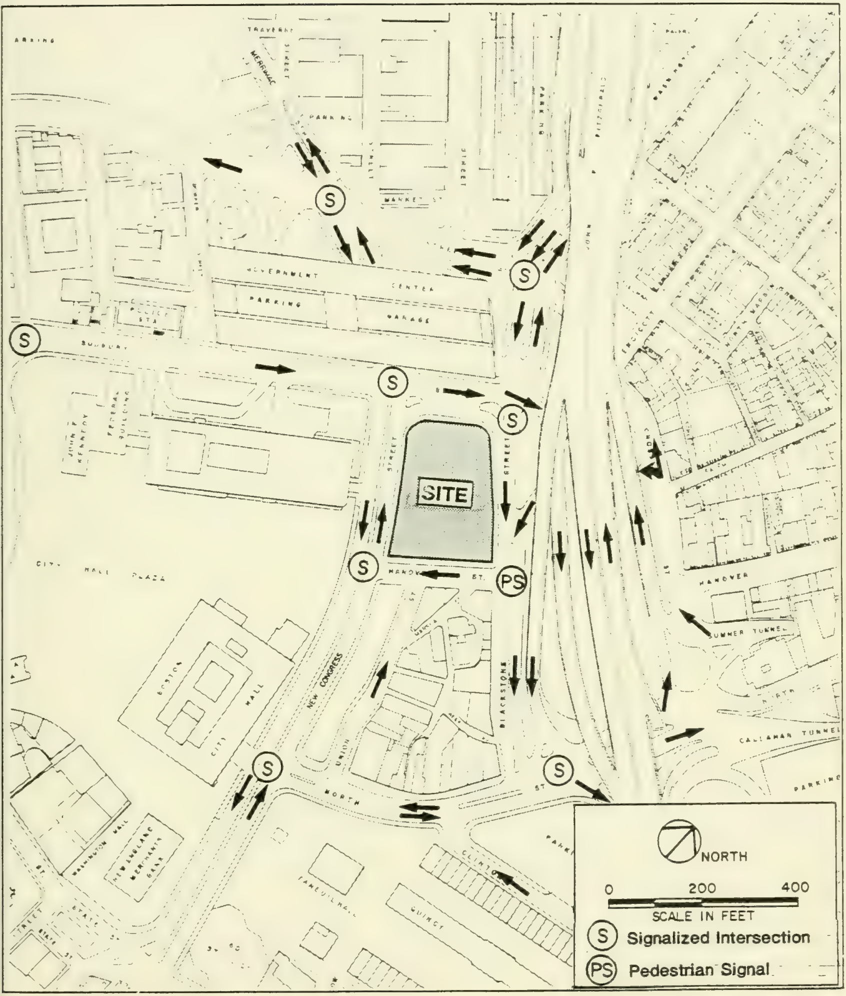


Figure 4 Existing Daily Traffic

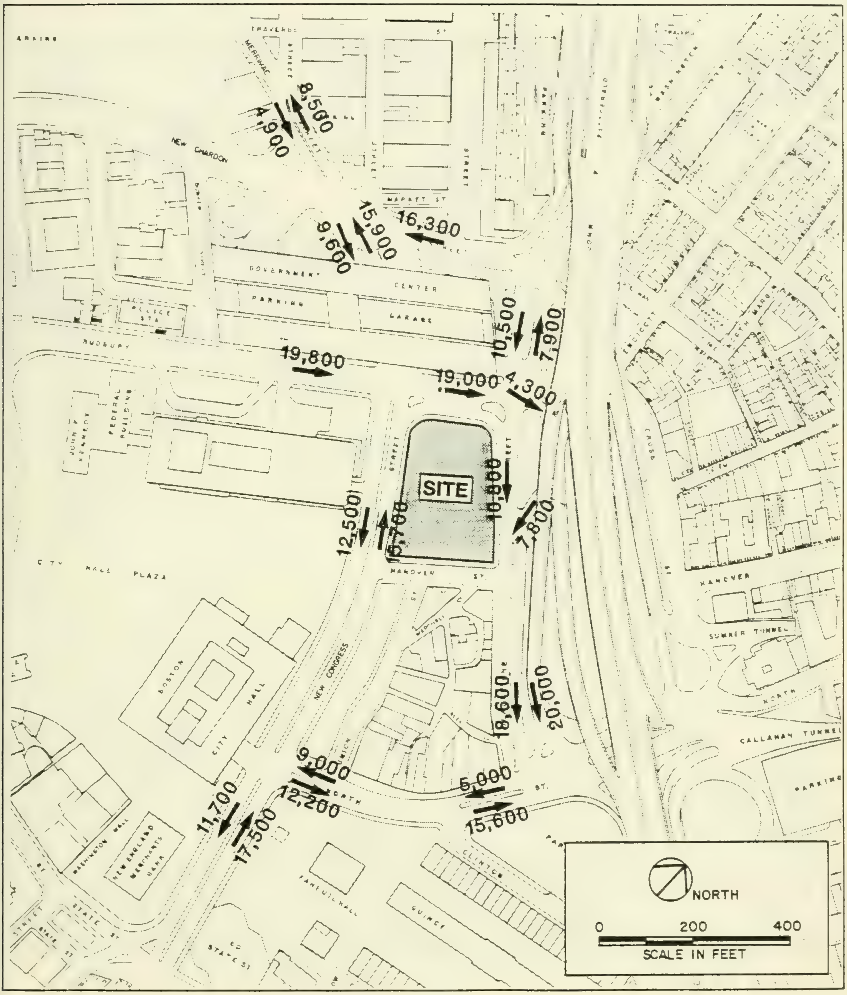


Figure 5

Existing A.M. Peak Hour Volumes

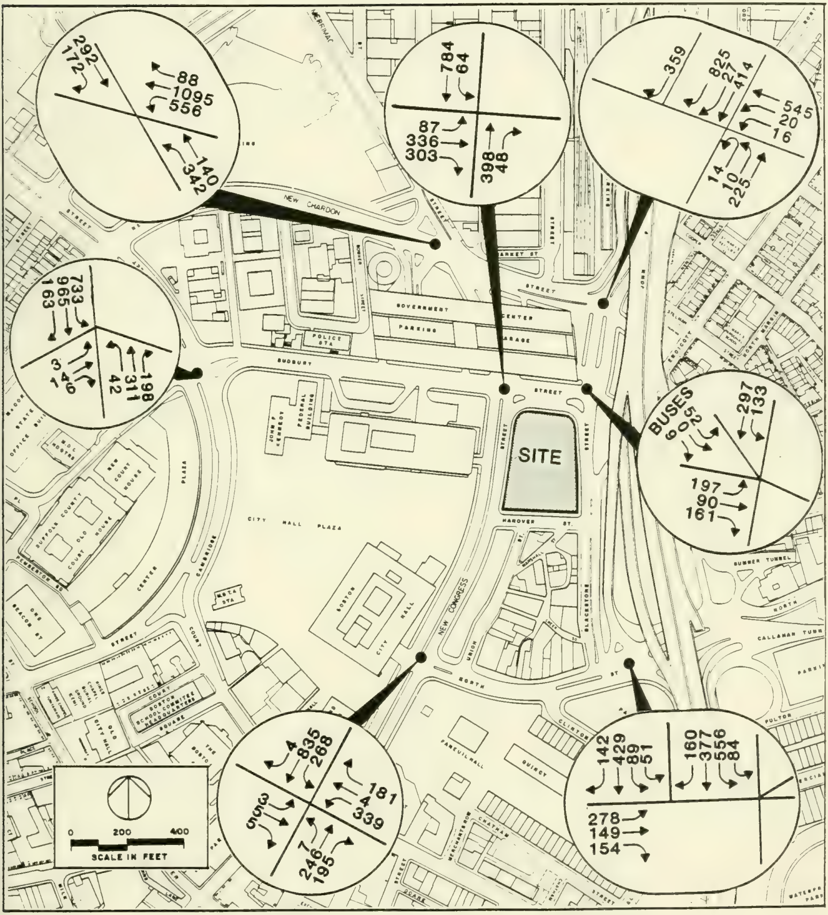


Figure 6

Existing P.M. Peak Hour Volumes

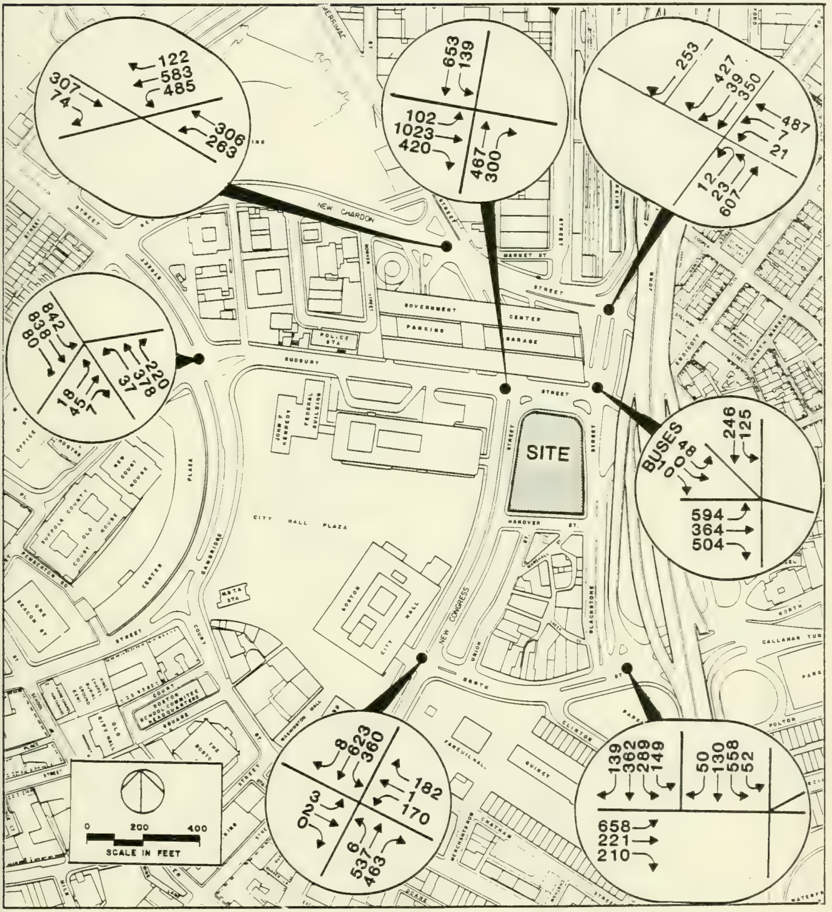
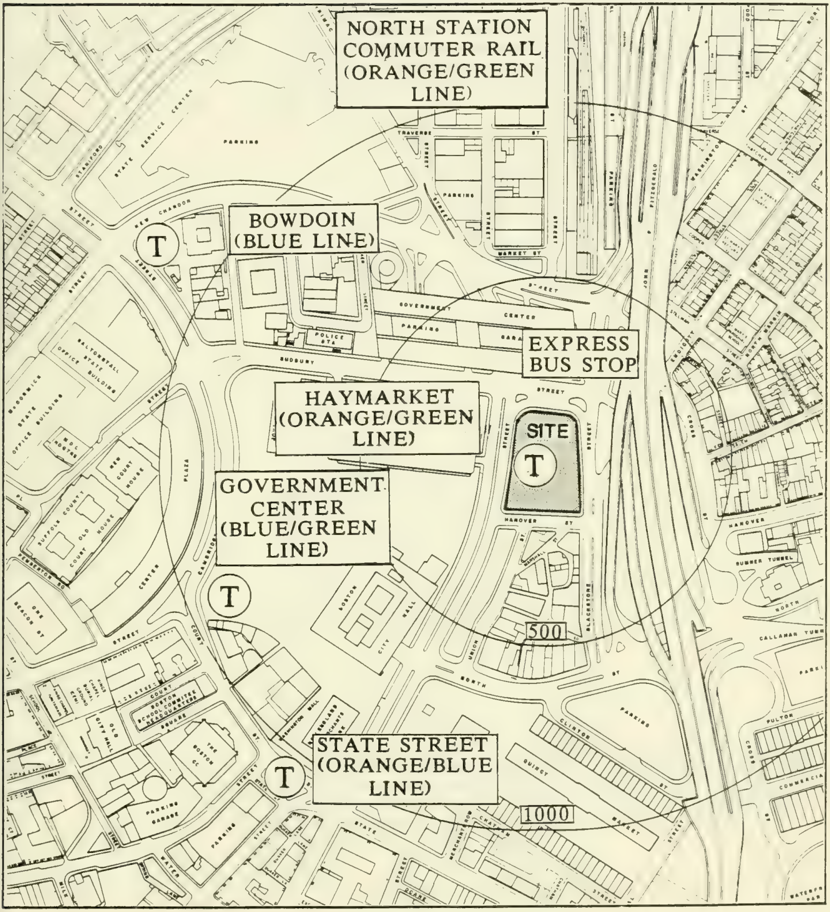


Figure 7

Location of Public Transportation


NORTH STATION COMMUTER RAIL (ORANGE/GREEN LINE)
BOWDOIN (BLUE LINE)
T
EXPRESS BUS STOP
HAYMARKET (ORANGE/GREEN LINE)
SITE
T
GOVERNMENT CENTER (BLUE/GREEN LINE)
T
500
STATE STREET (ORANGE/BLUE LINE)
T
1000

provided on the site and at the northeast end of the Government Center Garage. South and southwest of the site are the State Street (Orange and Blue Lines) and Government Center Stations (Green and Blue Lines). Access to the Red Line is available at the Park and Washington Stations, several blocks southwest of the site, either on foot or via Green or Orange Line transfers.

TABLE 2

LOCAL STREET TRAFFIC VOLUME SUMMARY

Street Segment	Daily Volume (vpd)[1]	AM Peak Hour		PM Peak Hour	
		Volume (vph)[2]	"K"[3] Factor	Volume (vph)	"K" Factor
Sudbury St. (eastbound)	19,000	640	3.4%	1,640	8.6%
Blackstone St. (southbound)	18,600	720	3.8%	1,180	6.3%
North St. (eastbound)	15,600	610	3.9%	1,180	7.6%
North St. (westbound)	5,000	310	6.2%	200	4.0%
New Congress St. (northbound)	15,700	944	6.0%	1,440	9.2%
New Congress St. (southbound)	12,500	565	4.5%	975	7.8%

[1] vpd = vehicles per day

[2] vph = vehicles per hour

[3] "K" Factor = percent of average daily traffic.

Express Bus Service

The area is well served by commuter bus service, with MBTA express service provided to the Haymarket area from the north and to the Financial District from the west. Additional commuter bus service by private carriers is provided to the Haymarket area and to South Station.

The bus terminal points are within easy access of MBTA rapid transit lines, which further enhances access to the site.

These lines are well used and it is the MBTA's policy to encourage continued use by minimizing standees. Consequently, the MBTA will add buses as demand warrants.

Commuter Rail Service

In addition to the rapid transit system, the MBTA operates an extensive commuter rail system with one terminus at North Station (service to northern suburbs), a short distance from the site, and one terminus at South Station (south and west division), about three-quarters of a mile from the site. The system is operated by the Boston & Maine Railroad under contract to the MBTA and provides access to the rapid transit system at its terminus points.

In total, there are eight branches serving the north, west and south. According to the MBTA, additional cars are added when it becomes necessary to meet demand.

Pedestrians

Existing AM and PM peak hour pedestrian volumes were monitored at the intersections of Sudbury Street/New Congress Street, Sudbury Street/Blackstone Street, Blackstone Street/Hanover Street, and New Congress Street/Hanover Street. In addition, mid-block crossings were monitored. Figures 8 and 9 show existing AM and PM pedestrian movements by location and direction of travel.

Study area pedestrian flows during the morning peak hour show a general north-to-south pattern across Sudbury Street and along New Congress Street. Westbound crossings of New Congress Street are also significant. Much of this traffic represents walk trips to/from the Haymarket bus and rapid transit stations, the North End, North Station, Government Center Parking Garage, JFK Federal Building, City Hall or the Financial District. The major direction of pedestrian flow is generally reversed in the evening peak hour.

Figure 8

Existing A.M. Pedestrian Movements

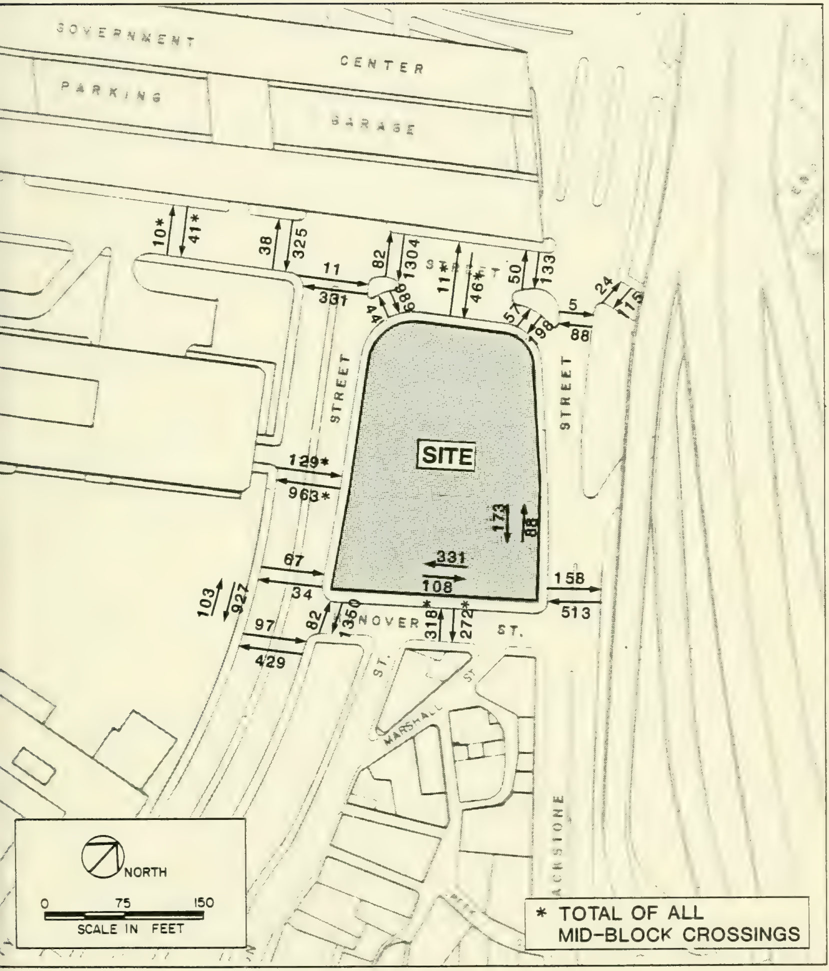
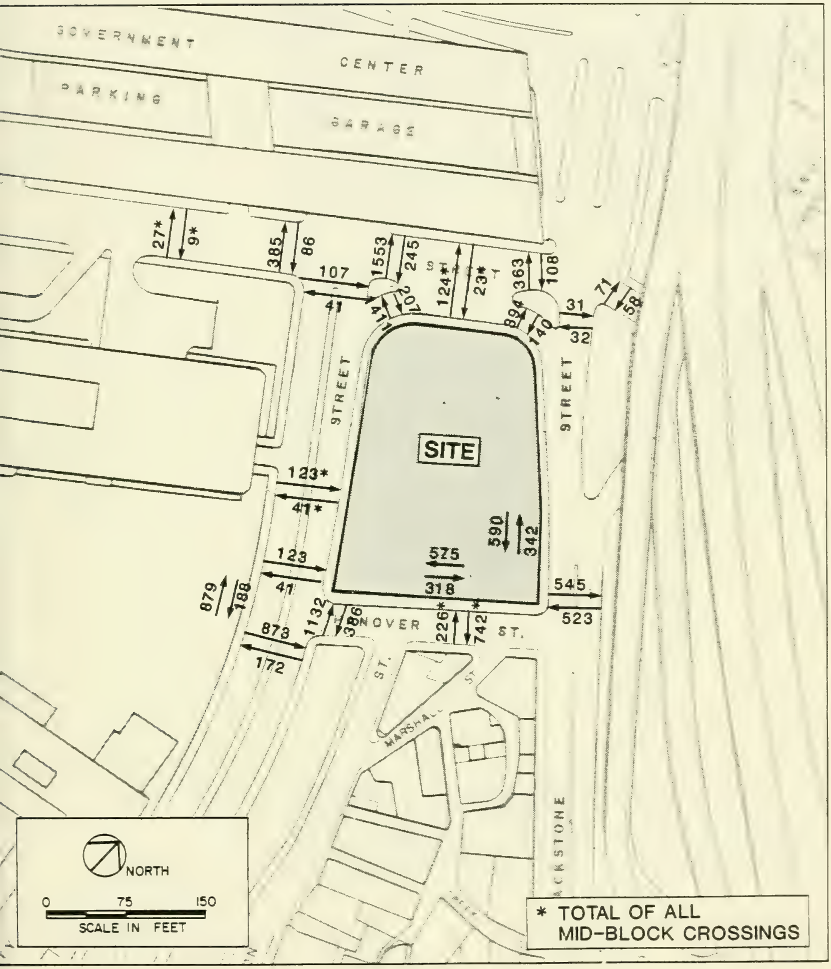


Figure 9

Existing P.M. Pedestrian Movements



Parking

Parking in Downtown Boston is a primary concern to the potential developer and other business and residential property owners. Parking in the downtown area is at a premium. According to a citywide survey, on-street parking is fully used while off-street spaces are used to 93 percent of capacity during the peak time of the day (12 Noon to 2 PM). However, parking demands are not uniform and vary by type of parker and location in the City. Long-term or commuter parking tends to be located in off-street facilities while on-street parking generally accommodates high-turnover shopper parking.

Off-Street Parking in the Government Center Area

Within 1,500 feet of the project site (about a five-minute walk) there are almost 50 different parking facilities ranging in size from small, 10-15 space private lots to the 1,886-space Government Center Garage, according to a 1982 citywide survey. These facilities provide a total off-street supply of approximately 5,100 parking spaces. Table 3 summarizes the parking supply in the area in relation to the proposed site.

TABLE 3
PARKING SUPPLY NEAR THE STUDY AREA

Distance from Site (feet)	Parking Supply
Less than 500	2,466
500-1,000	926
1,000-1,500	1,712
Total	5,104

A parking study conducted for the City of Boston included field observations of parking activity at all off-street parking lots in the area. Parking accumulation was noted during two times of the day -- 10:00 AM and 12:00 Noon -- on several days during October, 1982.

The results of this survey at the large facilities near the proposed site are summarized in Table 4, which shows that the noon hour accumulation exceeds the capacity at most facilities.

TABLE 4
1982 PARKING OBSERVATIONS AT SELECTED FACILITIES[1]

Facility Name Or Location	Rated Capacity	Actual Noon Hour Usage
1-37 Commercial Street	597	698
15 Cross Street	65	24
99 Cross Street	142	109
New Congress Street[2]	150	203
Cambridge Street - A	23	27
Cambridge Street - B	180	174
Government Center	1,886	1,881
Total	3,043	3,116

---

[1] Source: "Parking in Central Boston: Meeting the Access Needs of a Growing Downtown," prepared for Boston Traffic and Parking Department, December, 1983.

[2] Located on Parcel 7.

In addition, four facilities were surveyed during the 1984 Parcel 7 development study. Three of the facilities are common to the 1982 survey, and all are over capacity. The results of the 1984 survey are summarized in Table 5.

As a result of these surveys, it is clear that there is a current shortfall of long-term parking in proximity to the study area.

TABLE 5
1984 PARKING OBSERVATIONS

Facility Name Or Location	Rated Capacity	Actual Noon Hour Usage[1/]
15 Cross Street	65	84
99 Cross Street	142	162
New Congress Street[2/]	150	178
Under Central Artery, East of Government Center Garage	31	42
Total	388	466

[1/] From field survey.
[2/] Located on Parcel 7.

On-Street Parking in the Government Center Area

As with the off-street parking system, curbside parking appears to be used to capacity throughout most of the day. The Boston Parking Survey identified nearly 1,100 vehicles parked on-street in the vicinity of the Government Center/West End sections of Boston at 12 Noon. Virtually all of the available curbspace was utilized.

Future Transportation Improvements

The Boston Transportation Department is actively engaged in improvements to the signal systems in the Downtown area. The objective is centralized computer control of all subsystems. Existing controls are scheduled to be upgraded using real-time detection of traffic volume and density on selected links. Based on measured activity, one of several timing plans will then be brought into use. Phase 1 of this effort encompasses the Downtown and Financial Districts, including the study area. Implementation is scheduled for March, 1990.

As a result of the North Station Urban Renewal Project, two transportation improvements have been planned. The widening of Merrimac Street/Lomasney Way to two lanes in each direction will carry through traffic between Leverett Circle and the Haymarket/Government Center area.

Construction of these improvements is uncertain, however it is hoped construction will start in 1987 and be completed in 1988. Several alternatives are also presented for relocation of the MBTA's Green Line in this area. No timetable is available.

In addition to its potential relocation in the North Station area, the Green Line is scheduled for improvements to its vehicle fleet. New light rail vehicles (LRV) will be purchased which meet revised specifications, helping to alleviate recent equipment problems on the line. Over the next year or two, the MBTA expects to take delivery of 50 new vehicles. Another 50 may be ordered for delivery within the next three to four years.

As part of the planned Government Center Parking Garage improvement project, the Merrimac Street and northern New Chardon Street entrances will be eliminated. At the southern New Chardon Street entrance, the three entering lanes will be angled to provide greater queue capacity. In addition, exit lanes to Sudbury Street will be increased from two to three lanes. Construction is scheduled to start in the summer of 1986 and last for 18 months. When complete, the project will include new office (249,000 square feet) and retail (21,000 square feet) space, as well as an increase of parking spaces from 1,886 to 2,086 through restriping of the existing facility.

Although the depression of the Central Artery is a much longer-range improvement and is scheduled beyond the analysis year for the Parcel 7 development, it should be noted that this improvement as presently designed requires the elimination of Blackstone Street between Sudbury and Hanover Streets, while the rest of Blackstone Street will serve only local traffic. However, a new road connecting New Chardon and Sudbury Streets to North Street will be constructed just east of Blackstone Street. The project will eventually be linked to this new road.

Future Travel Demands

An estimate of project-generated traffic, as well as other development demands, was made using travel factors from various sources, including available reports and surveys of existing conditions. The Technical Appendix

includes details on trip generation rates, mode split percentages, vehicle occupancy rates, peak hour percentages and other travel demand factors. This section highlights the key elements and results of the analysis.

Person Trips

Table 6 summarizes the total number of person trips estimated to be generated by the project in 1989. On a daily (Friday) basis, 7,311 two-way person trips are projected, about one-half in vehicles, about one-third via public transportation, and the rest on foot. The morning and afternoon peak hours will account for 667 (9.1 percent of the daily total) and 895 (12.2 percent of daily) person trips, respectively, with about the same distribution among vehicle, transit and walk modes.

TABLE 6
1989 PARCEL 7 PERSON TRIPS BY MODE[1/]

Mode		Daily	AM Peak Hour	Percent of Daily	PM Peak Hour	Percent of Daily
Vehicle	Number	3,599	312	8.7	433	12.0
	Percent	49.2	46.8		48.4	
Transit	Number	2,593	269	10.4	337	13.0
	Percent	35.5	40.3		37.6	
Walk	Number	1,119	86	7.7	125	11.2
	Percent	15.3	12.9		14.0	
Total	Number	7,311	667	9.1	895	12.2
	Percent	100.0	100.0		100.0	

[1/] Total to and from the site.

Parcel 7 Vehicle Trips

Person trips were converted to vehicle trips using the vehicle occupancy rates shown in the Technical Appendix. As discussed earlier, a Friday analysis condition was used for vehicle impacts due to pushcart activity which reduces vehicular capacity on Blackstone Street and blocks Hanover Street completely. It was also assumed

that all who wished to drive to the site would have a parking space available. This represents a worst-case traffic condition. Table 7 summarizes 1989 vehicle trips generated by the project. There will be 1,967 daily trips (on a Friday), including 192 and 222 during the morning and afternoon peak hours, respectively. Most vehicle trips will be generated by the hotel: about 72 percent on a daily basis and about 57 percent during the peak hours. Included in the total number of hourly vehicle trips are only about five to six hotel delivery trucks (0.12 trucks per day per room over an eight-hour day) and two to three office delivery trucks (0.21 trucks per day per 1,000 square feet over an eight-hour day). Retail truck activity is negligible.

TABLE 7
1989 VEHICLE TRIPS
GENERATED BY PARCEL 7 DEVELOPMENT[1/]

Use	Daily	AM Peak Hour	PM Peak Hour
Office	461	80	90
Percent of Total	23.4	41.7	40.5
Retail	78	1	6
Percent of Total	4.0	0.5	2.7
Hotel	1,428	111	126
Percent of Total	72.6	57.8	56.8
Total	1,967	192	222
	100.0	100.0	100.0

[1/] Friday analysis conditions.

Background Development Vehicle Trips

Travel demands generated by other development projects either being planned or under construction in the area of Parcel 7 were also identified. Several major projects were included. These are identified in Table 8, along with the estimated number of vehicle trips projected for each as obtained from impact reports filed for each project or, in the case of the Government Center Garage project, estimated directly from the travel demand factors presented in the Technical Appendix for the

Parcel 7 project. Vehicle trips for the Exchange Place project were added even though it is now occupied, since it was under construction at the time of the 1984 traffic counts used as a base for the Parcel 7 project.

Trip Distribution

Vehicle trips generated by the Parcel 7 project and other background developments were distributed over the available roadway system, based on available travel patterns in the Downtown area. All retail and office trips, along with hotel employee trips, were distributed separately from trips made by hotel visitors due to the different characteristics of each group. Table 8 presents trip distribution by geographic corridor for all project-generated trips. This distribution pattern is also shown in Figure 10.

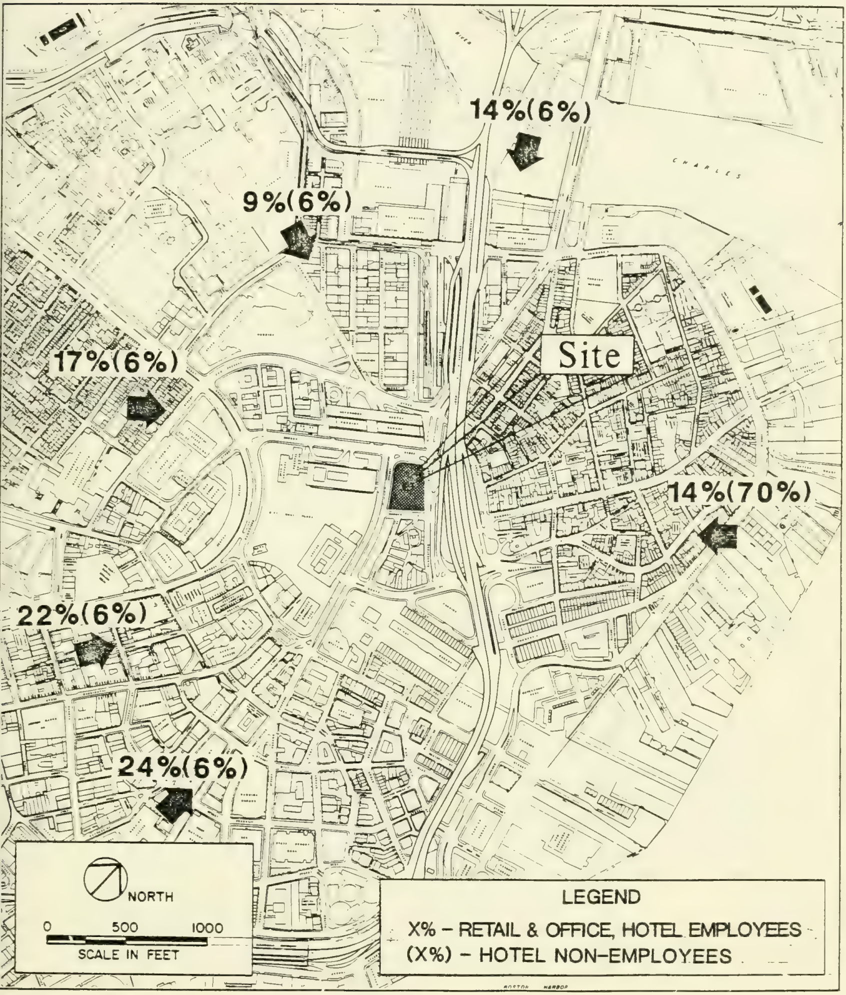
TABLE 8
1989 VEHICLE TRIPS GENERATED BY
OTHER NEW DEVELOPMENTS

Development	Daily	AM Peak Hour	PM Peak Hour
North Station Urban Renewal Project (GSA Building)	6,970	1,105	1,181
Marketplace Center	1,660	205	265
Government Center Garage/Office/Retail	960	137	170
Custom House	634	76	91
Exchange Place (53 State Street)	2,140	751	751
75 State Street formerly 99 State Street)	1,726	309	317
Auto-Veyor Parking	337[1/]	118	105
Total	14,427	2,701	2,880

[1/] Daily volume occuring only between the hours of 8:00 AM and 6:00 PM.

Figure 10

Trip Distribution By Corridor



PROBABLE PROJECT IMPACTS

Roadway Impacts

The analysis of roadway impacts has been conducted for two 1989 conditions. First, the expected traffic increases related to developments other than the Parcel 7 development have been added to the observed existing volumes to develop a future No-Build network. Morning and evening peak hour volumes are shown in Figures 11 and 12, respectively. Second, the expected traffic increases related to the 1989 Parcel 7 development have been added to the first 1989 network to develop a future Build network. The 1989 AM and PM peak hour networks with the Parcel 7 development are illustrated in Figures 13 and 14, respectively. It should be noted that the project's access drive (designated as the through-block connector) is proposed to allow both in and out movements at the New Congress Street end and in only at the Blackstone Street end.

Table 9 compares the differences between the two 1989 network conditions. Traffic volume increases are generally fairly uniform among the streets in the study area due to the direction of the through-block connector, the adjacent street system's one-way pattern, and the trip distribution pattern. The increases are also fairly modest in both absolute and in percentage terms.

The largest increase in peak hour traffic occurs on New Congress Street (north of the through-block connector) which would result in an average increase of three vehicles per minute during the evening peak hour. The increases on this link are due to the routing of all exiting volumes from the site onto this segment.

Intersection Analysis

Level of Service (LOS) is a term used to denote the operating conditions on a roadway and is qualitatively measured as the effect of speed, delay, freedom to maneuver and safety. At Level of Service "A", an intersection operates at free-flow conditions. Typically, the intersection approach appears quite open and turning movements are made easily. Seldom, if ever, does a driver have to wait through more than one red signal indication.

Figure 11

1989 No Build A.M. Peak Hour Volumes

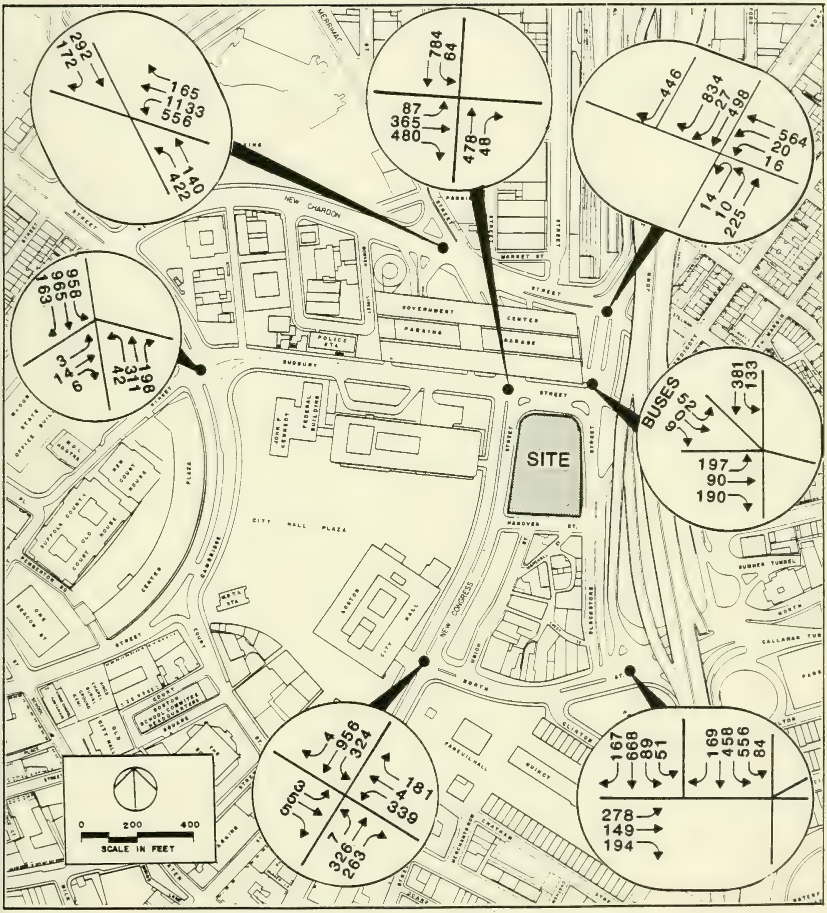


Figure 12

1989 No Build P.M. Peak Hour Volumes

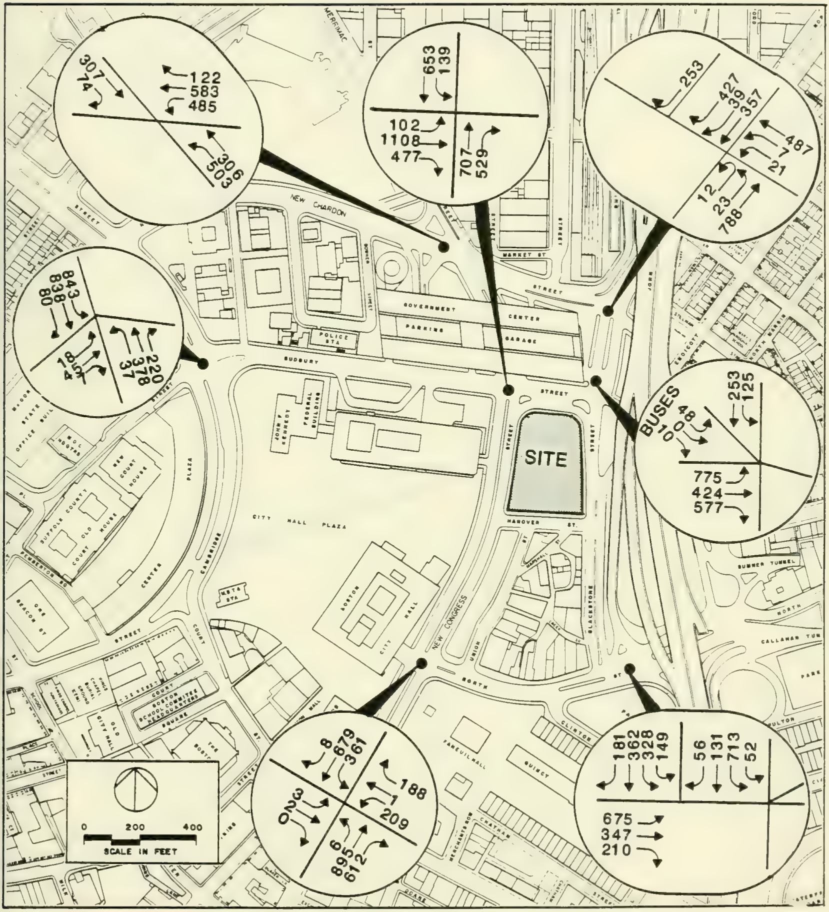


Figure 13

1989 Build A.M. Peak Hour Volumes

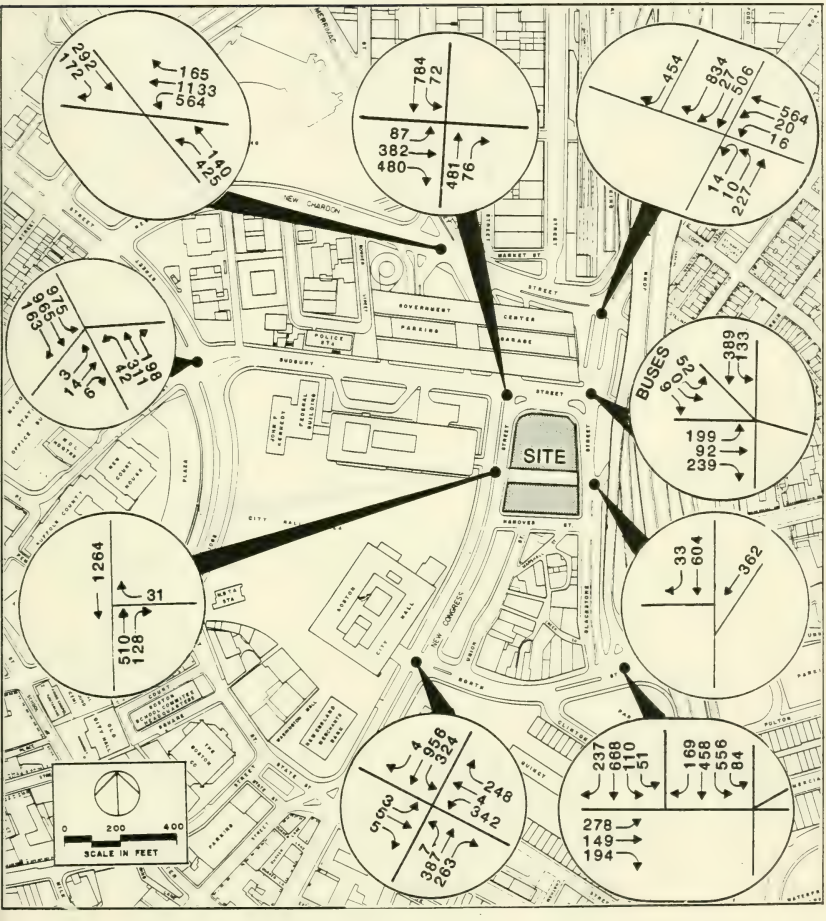


Figure 14

1989 Build P.M. Peak Hour Volumes

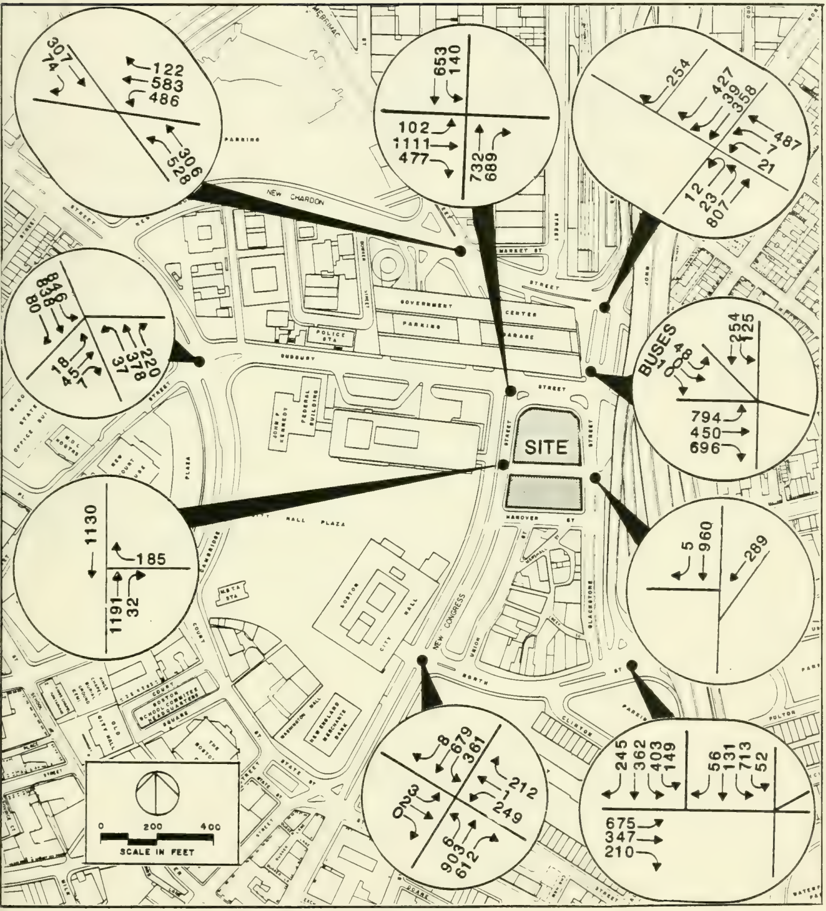


TABLE 9
1989 PEAK HOUR TRAFFIC INCREASES ON SELECTED ROADWAYS

Roadway	Peak Hour	Traffic Volume (vph)[1/] No-Build	Build	Increase	Percent Increase
New Congress Street	AM	1,794	1,922	128	7.1
(North Street to Site Drive)	PM	2,134	2,166	32	1.5
New Congress Street	AM	1,790	1,821	31	1.7
(Site Drive to Sudbury)	PM	2,366	2,551	185	7.8
Merrimac Street	AM	1,413	1,424	11	0.8
(Sudbury to New Chardon)	PM	1,601	1,627	26	1.6
Sudbury Street	AM	477	530	53	11.1
(New Congress to Blackstone)	PM	1,776	1,940	164	9.2
Blackstone Street	AM	580	637	57	9.8
(Sudbury to Site Drive)	PM	840	960	120	14.2
Blackstone Street	AM	975	1,066	91	9.3
(Site Drive to North Street)	PM	1,020	1,159	139	13.6
North Street	AM	957	1,027	70	7.3
(Blackstone to New Congress)	PM	1,413	1,533	120	8.5

[1/] vph = vehicles per hour

Capacity of the intersection occurs at Level of Service "E" and is characterized by consistent backups or queues of vehicles waiting to pass through the intersection. Capacity represents the maximum number of vehicles that can be processed during a given time frame. At capacity conditions, vehicles will always be waiting on approach roadways to use signal green time. In this situation, some motorists may experience significant delays and be forced to wait. There are many intersections in the Boston metropolitan area which operate at capacity levels during peak demand periods. Volumes in excess of the estimated capacity of an intersection represent Level of Service "F".

The analysis is based on the sum of critical volumes from each intersection approach and the ratio of this volume to capacity. The capacity is equal to the maximum sum of critical volumes associated with Level of Service "E". Basic level of service criteria are shown in Table 10. For each individual intersection, these critical-volume criteria were reduced by the percent of potential green time lost to exclusive pedestrian phases to account for pedestrian activity in the study area.

TABLE 10
LEVEL OF SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS[1/]

	Maximum Sum of Critical Volumes			
Level of Service	Two Phase	Three Phase	Four Phase	Volume/ Capacity Ratio
A	900	855	825	0.00-0.60
B	1,050	1,000	965	0.61-0.70
C	1,200	1,140	1,100	0.71-0.80
D	1,350	1,275	1,225	0.81-0.90
E	1,500	1,425	1,375	0.91-1.00
F	Not Applicable			1.01+

[1/] Transportation Research Circular Number 212. "Interim Materials on Highway Capacity," Transportation Research Board, Washington, D.C., January 1980.

Table 11 summarizes the results of the intersection level of service analysis. Level of service is graphically summarized for morning and evening peak hours in Figures 15 and 16, respectively. It should be noted that the intersection of North Street/Blackstone Street was analyzed as a signalized intersection even though the existing signals have been set on flashing operation by the Boston Transportation Department. Operating conditions should be substantially similar under both signal strategies.

In no case does the level of service decrease from the 1989 No-Build to Build conditions. The North Street intersection with Blackstone Street will operate at Level of Service "F" in both the morning and evening peak hours under both No-Build and Build conditions. This intersection currently operates at Level of Service "F" with V/C ratios of 1.09 and 1.03 in the morning and evening peak hours, respectively. The intersection of North Street and Congress Street will also operate at Level of Service "F" in the evening peak hour under both No-Build and Build conditions, although it will operate at Level of Service "D" in the morning peak hour.

It should be noted that although the southbound Blackstone Street approach is striped for two lanes, the inside lane is blocked by delivery trucks during the entire morning peak hour, and intermittently during the evening peak hour, due to the Friday pushcart activity in the Haymarket. Therefore, the analysis at this intersection assumes only a one-lane approach in the morning peak and only one lane for half of the evening peak. Since Friday is the only weekday when this occurs, the intersection will operate substantially better during all other days of the week when lane blockage does not occur. Mitigation measures to alleviate Friday conditions are discussed later in the report.

Through-Block Connector Analysis

A through block connector is planned through the project site between New Congress and Blackstone Streets, which will allow access into the proposed development from both New Congress and Blackstone Streets with only one exit onto New Congress Street. The New Congress Street junction of this proposed roadway was analyzed as an unsignalized intersection to identify how it would

TABLE 11
INTERSECTION LEVEL OF SERVICE ANALYSIS

Intersection	Peak Hour	Existing V/C[1/]	Existing LOS[2/]	1987 No-Build V/C	1987 No-Build LOS	1987 Build V/C	1987 Build LOS
New Chardon Street/	AM	0.63	B	0.69	B	0.69	B
Merrimac Street	PM	0.54	A	0.56	A	0.57	A
New Chardon Street/	AM	0.51	A	0.53	A	0.54	A
North Washington Street	PM	0.39	A	0.45	A	0.45	A
Sudbury Street/	AM	0.56	A	0.65	B	0.66	B
Cambridge Street	PM	0.64	B	0.64	B	0.64	B
Sudbury Street/Congress	AM	0.48	A	0.53	A	0.53	A
Street/Merrimac Street	PM	0.66	B	0.83	D	0.88	D
Sudbury Street/	AM	0.25	A	0.28	A	0.30	A
Blackstone Street	PM	0.44	A	0.49	A	0.58	A
North Street/	AM	1.09	F	1.28	F	1.37	F
Blackstone Street	PM	1.03	F	1.17	F	1.26	F
New Congress Street/	AM	0.75	C	0.82	D	0.83	D
North Street	PM	0.92	E	1.07	F	1.11	F

[1/] V/C = volume to capacity ratio. Theoretical capacity = 1.00.
[2/] LOS = level of service.

Figure 15

A.M. Peak Hour Level of Service

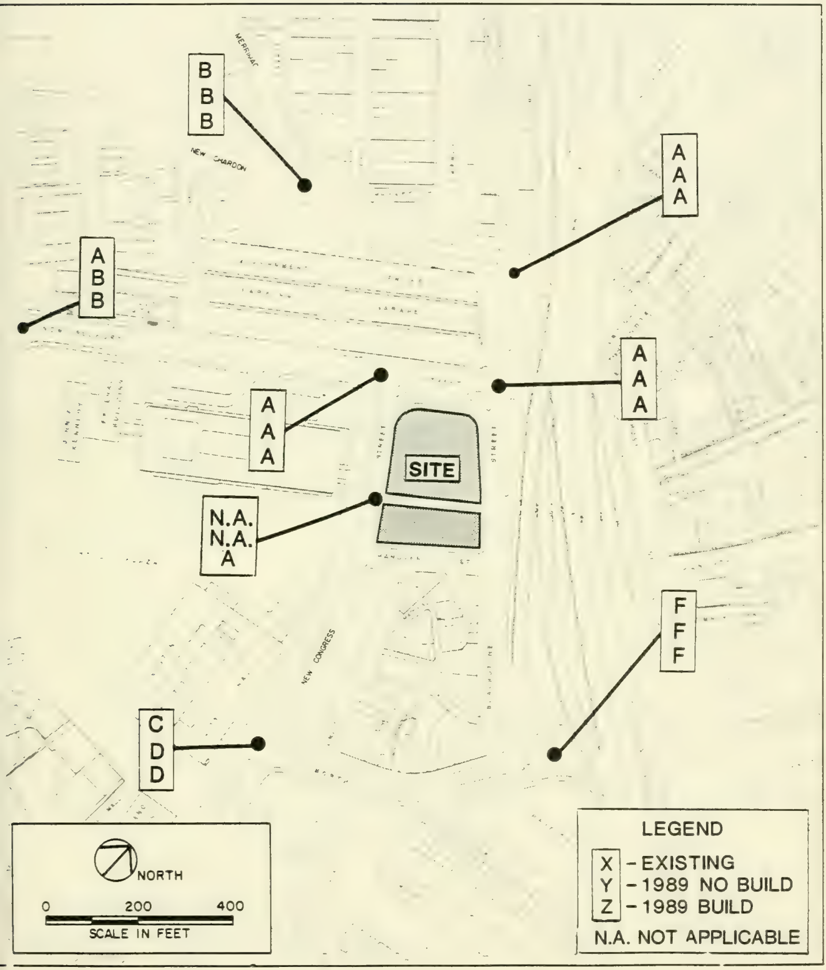
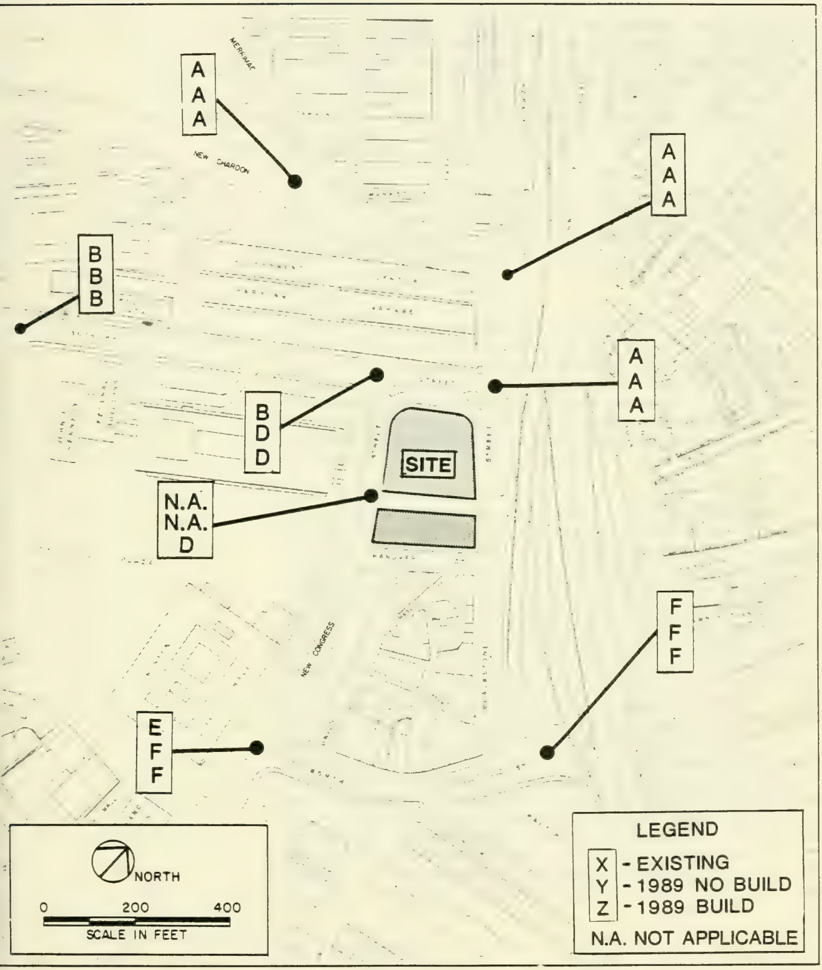


Figure 16

P.M. Peak Hour Level of Service



operate with the estimated 1989 AM and PM peak hour traffic volumes shown in Figures 13 and 14, previously. The analysis involves estimating the percentage of acceptable gaps available for vehicles exiting the connector. The result is LOS "A" in the morning peak hour due to the relatively small number of peak-hour vehicle trips leaving the site and LOS "D" in the evening peak hour.

The intersection of the through-block connector on Blackstone Street does not lend itself to such an analysis since only a right-turn from the major roadway into the minor roadway (the connector) is involved. Therefore, no problem will be encountered here due to the one-way flow inbound.

The width of the connector will provide for good traffic flow on the connector itself, with recessed curb cuts to handle auto drop-offs/temporary stopping on both sides of the connector. A taxi waiting area has been proposed at the Hanover Street/Union Street intersection which, in conjunction with a hotel entrance/exit at New Congress Street/Hanover Street, will reduce vehicle activity on the connector itself.

It should be noted that the original concept for the through-block connector involved one-way eastbound flow from New Congress Street to Blackstone Street. Analysis of this pattern indicated that the most significant traffic impacts would be on the two busy North Street intersections (at Blackstone and New Congress Streets) due to circuitous circulation. Based on these results, the project proponent modified the pattern to the present configuration. This improved V/C ratios at the North Street/Blackstone Street intersection from 1.41 to 1.37 in the AM and from 1.32 to 1.26 in the PM. Benefits realized at the North Street/New Congress Street intersection were from 1.14 to 1.11 in the PM (the AM remained the same at 0.83). Slight increases occurred at several locations to the north of the project site where intersection operation is in the good-to-acceptable range. This mitigation measure was built into the project at the analysis stage by the proponent rather than at the approval stage. Additional mitigation measures are proposed in a subsequent section.

Delivery Vehicle Impacts

As noted earlier, only five to six hotel delivery trucks per hour and two to three office delivery trucks per hour are anticipated, which should be accommodated easily by the project's four loading docks (three hotel and one office). This low level of activity is not expected to have any adverse effect on through traffic in Blackstone Street where the loading docks are located. Although trucks backing into the docks will cause some intermittent disruption to through traffic, the main capacity constraint is at the Blackstone Street/North Street intersection, which will not be affected by these maneuvers. Also, the project proponent has agreed to certain mitigation actions to relieve peak hour impacts.

Parking Impacts

Project Parking Demand

The number of parking spaces required by the project can be estimated by employing the same assumptions used in the trip generation forecasts for the project. Parking requirements are divided into long-term employee parking and short-term business parking. Based on the travel forecasts, it is estimated that the proposed project at full development will generate a theoretical demand for 455 parking spaces, broken down by type as follows:

	Office	Retail	Hotel	Total
Long-term (work)	127	6	35	168
Short-term[1] (non-work)	39	12	236	287
Total	166	18	271	455

---

[1] Based on the survey of the Holiday Inn on Cambridge Street in Boston, it is estimated that 35 percent of vehicle trips are by taxi, and would not require a parking space. To be conservative, it was assumed that only hotel non-employee (short-term) trips would be made by taxi.

Project Parking Supply/Demand Summary

The proposed Parcel 7 development will include parking for about 400 vehicles. With the exception of the short-term spaces for office and retail (39 office + 12 retail = 51 total), the project will be able to accommodate approximately its theoretical parking demand (404) with the anticipated supply of 400 spaces, as indicated in the parking demand summary tabulation in the previous section. The 51 short-term office and retail parkers can be served at the proposed 135-space Auto-Veyor parking facility proposed beneath Curley Park. The existing 150-space lot on the project site used for all-day permit parking for City employees will not be replaced on the site. The City has indicated that this need not be included in the overall parking supply/demand analysis for the project since the City itself will either replace some or all of these spaces elsewhere or handle the demand with ridesharing/transit incentives.

Transit Impacts

The proposed project is expected to generate approximately 300 outbound transit trips in the heavier evening peak hour (246 inbound in the AM peak hour). Based on the 1982 cordon counts for Downtown Boston, 70 percent of transit trips are made by rapid transit. Therefore, a total of 210 outbound PM peak hour rapid transit trips can be expected to be generated by the proposed development. The assignment of project rapid transit trips is shown in Table 12.

TABLE 12
ASSIGNMENT OF RAPID TRANSIT TRIPS GENERATED
BY PROJECT DEVELOPMENT - PM PEAK HOUR OUTBOUND

Line/Direction	Percent Distribution	Project Trips
Red/North	12	25
Red/South	23	48
Blue/North	12	25
Orange/North	20	42
Orange/South	14	30
Green/West	17	36
Green/East	2	4
Total	100	210

Passengers on the Green and Orange Lines are expected to board at the on-site portal to Haymarket Station. Blue Line passengers will walk to Government Center or State Street to board. All Red Line, commuter rail and commuter bus passengers leaving South Station are assumed to board the Green or Orange Line at Haymarket and then transfer to the Red Line at Park Street or Washington in order to reach South Station. In order to be conservative, commuter rail passengers out of North Station are also assumed to board the Green or Orange Lines at Haymarket. In actuality, many of these passengers may walk directly to the loading points of their final transit mode, although it was decided to conservatively assume most transit passengers will load at Haymarket due to the convenience. Based upon these assumptions, 229 passengers can be expected to board rapid transit lines via the on-site portal to Haymarket Station.

These levels of new transit riders can be absorbed by the rapid transit lines serving the site with little, if any, impact.

Pedestrian Impacts

Future project-generated pedestrian trips (which include both "walk mode" and "transit mode" previously discussed) have been identified as follows: AM peak hour - 355; PM peak hour - 462. Through review of transit station locations and an estimated sub-mode split (70 percent rapid transit, 23 percent bus and 7 percent commuter rail, based on the 1982 Cordon Count, peak hour walk trips have been assigned by percentage to streets and directions of travel. The actual pedestrian trips generated by the project are shown in Table 13.

As can be seen from a comparison of Table 13 with existing peak hour pedestrian volumes (see Figures 8 and 9), project-related pedestrian trips represent a minimal increase. Existing AM peak hour pedestrian trips total about 2,300 from all directions toward the site, compared to 318 new incoming trips (355 two-way) generated by the proposed development. Similarly, PM peak hour trips currently total about 3,700 away from the site, as opposed to 401 new outbound trips (462 two-way) to be added. A conservative sidewalk capacity analysis indicates that expected pedestrian flow rates on Congress Street are likely to result in good levels

of service (B to C range) in the peak hours, with or without the new pedestrian activity generated by the project. Levels on other streets will be considerably less. Therefore, no significant impact to the surrounding sidewalk system is anticipated due to the project.

TABLE 13
PARCEL 7 DEVELOPMENT
PEAK HOUR PEDESTRIAN TRIPS[1]

Direction[2]	Percent	AM Trips	PM Trips
North	30	106	139
South	20	71	92
East	10	36	46
West	25	89	116
Haymarket MBTA Station at Site[3]	15	53	69
Total	100	355	462

[1] Both directions (two-way).

[2] General direction relative to the project site.

[3] Trips generated to on-site MBTA station will not affect the area street system.

Construction Impacts

Construction Employee Trip Generation and Parking

The number of workers required over the two-year construction period will vary, but it is estimated that the peak at any given time will be about 125 workers. Trip generation by construction workers is a direct function of employment levels. Assuming an auto occupancy of two or three persons based on the shortage of parking, current costs of parking and the greater inclination of construction workers to carpool, the 125 employees during the construction period would generate from 42 to 63 trips each peak period if all employees commute by

automobile. In fact, a portion of the construction workers will likely utilize public transportation due to the downtown location of the site and its good accessibility via transit. In addition, construction workers generally travel before the peak hours, so they do not add to commuter peak hour traffic. Finally, given the many years of continuous construction activity in this area of the City, construction-related parking activity is already part of the background condition. As a result, no significant impact to the area roadway system is anticipated from construction worker vehicle trips.

It is assumed that for the first six to eight months of construction, any construction-generated vehicle trips will either park in available spaces in the area or that workers will shift to rapid transit. This assumption is reasonable in light of the recently completed Copley Place development, a large project for which no construction parking arrangements were made. The daily cost of off-street parking in the area will also encourage lower auto use. After the first six to eight months of construction, the project garage will be completed and could be made available for worker parking. Up to 100 spaces may be available during the remainder of the construction period.

Street Closure/Lane Blockage

It is anticipated that construction of both project buildings above ground level will proceed at the same time and take approximately 18 months. During that period, no street closures or travel lane blockages are proposed. However, the use of a narrow portion (no more than the curb lane) of New Congress, Blackstone and/or Hanover Streets is anticipated. Minimal impact would occur due to such activity since current curb lane usage precludes travel in these lanes. The curb areas would possibly provide space for a mobile crane which will service both buildings and provide for pickup of construction materials. The Haymarket pushcart operation would be affected only to the extent that the curb lane on Blackstone and Hanover Streets might be utilized for construction-related activity (see proposed Access Plan).

Delivery of Construction Materials

Major construction components are expected to be concrete, steel, brick and granite. All deliveries of construction materials and equipment will be made along the curb lane of either New Congress, Blackstone or Hanover Street, as noted above. As a result, unloading will not interfere with area traffic flow. Only two to three concrete trucks are expected to be at the site at any one time. This number of trucks can be accommodated at the same locations, thereby avoiding blocking lanes which carry through traffic.

The exact source locations of construction materials are not known at this time, but it is estimated that they will be roughly divided between north and south of the City. All deliveries from the north are expected to access the site via the Central Artery by exiting at New Chardon Street/Haymarket, while deliveries from the south would come via the Central Artery and exit at Atlantic Avenue/High Street or at North Station/Causeway Street. Returning vehicles would reach the Central Artery or Surface Artery directly from Blackstone Street. Because of the close proximity of the site to the Central Artery, trucks delivering construction materials should have a minimum impact on downtown streets.

Supplementary Analysis

The traffic analysis was conducted for three additional conditions:

1. Assuming a break in the New Congress Street median opposite the site entrance. This would give traffic from the north and west a more direct connection without passing through the congested North Street intersections with Blackstone Street and with New Congress Street. Analysis of this condition was requested by the Massachusetts Executive Office of Environmental Affairs, MEPA Unit.

2. Assuming an expansion of the proposed project sidewalk approximately 15 feet into Sudbury Street, resulting in the elimination of one travel lane. This condition was evaluated due to the City's interest in providing a stronger pedestrian linkage to the Government Center Parking Garage/Haymarket area.

3. Assuming both conditions described above.

The results of these analyses are summarized in Table 14. It can be seen that no change in level of service occurs with the introduction of the median break. As expected, the V/C ratio becomes slightly higher at the intersection of Sudbury/New Congress/Merrimac Streets in the morning peak hour, while the V/C ratio slightly declines in both peak hours at Sudbury/Blackstone Streets. The small changes reflect the relatively low volumes of trips to/from the north and west. In all cases, the addition of a median break would only result in a 0.01 change in V/C ratios. A gap analysis procedure used to describe traffic operations at unsignalized intersections was applied at the median break. Based on the technique, it has been determined that vehicles turning left into the site would operate at Level of Service "A" in the morning peak hour and Level of Service "B" in the evening peak hour. A lane of sufficient storage capacity could be provided in the existing wide median to safely hold left-turning vehicles.

The loss of capacity due to the expansion of the sidewalk into Sudbury Street is relevant only to the Sudbury Street/New Congress Street/Merrimac Street intersection. The loss of one lane on Sudbury Street and the right-turn lane into Sudbury Street does not affect the morning peak hour level of service, but the decrease in capacity reduces the evening operation from Level of Service "D" to "E".

The combination of the two alternatives also provides the same results as the median break alone, except at the Sudbury Street/New Congress Street/Merrimac Street intersection. Under these conditions, the results of the morning peak hour analysis remain essentially the same as the base case at this intersection, while the evening level of service decreases from Level of Service "D" to "E".

Generally, the various alternatives do not significantly affect traffic operations either adversely or beneficially. The only change in level of service (LOS "D" to LOS "E") occurs at the Sudbury Street/New Congress Street/Merrimac Street intersection due to the resulting loss of roadway capacity if the existing sidewalk is widened (pedestrian benefits will, of course, occur under this condition). There are some vehicular access

TABLE 14
INTERSECTION LEVEL OF SERVICE ANALYSIS
COMPARISON OF 1989 BUILD ALTERNATIVES

Intersection	Peak Hour	Base Case 1/		Median Break		Sidewalk Expansion 2/		Median Break & Expansion	
		V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS
New Chardon Street/ Merrimac Street	AM	0.69	B	0.69	B	0.69	B	0.69	B
	PM	0.57	A	0.57	A	0.57	A	0.57	A
New Chardon Street/ North Washington Street	AM	0.54	A	0.54	A	0.54	A	0.54	A
	PM	0.45	A	0.45	A	0.45	A	0.45	A
Sudbury Street/ Cambridge Street	AM	0.66	B	0.66	B	0.66	B	0.66	B
	PM	0.64	B	0.64	B	0.64	B	0.64	B
Sudbury Street/ New Congress Street/ Merrimac Street	AM	0.53	A	0.54	A	0.51	A	0.54	A
	PM	0.88	D	0.88	D	0.96	E	0.96	E
Sudbury Street/ Blackstone Street	AM	0.30	A	0.29	A	0.30	A	0.29	A
	PM	0.58	A	0.57	A	0.58	A	0.57	A
North Street/ Blackstone Street	AM	1.37	F	1.37	F	1.37	F	1.37	F
	PM	1.26	F	1.26	F	1.26	F	1.26	F
New Congress Street/ North Street	AM	0.83	D	0.83	D	0.83	D	0.83	D
	PM	1.11	F	1.11	F	1.11	F	1.11	F

1/ 1989 Build scenario analyzed previously.

2/ The modifications in this alternative only affect the Sudbury Street/New Congress Street/Merrimac Street intersection.

circulation benefits to be gained by users of the site from the north and west with the median-break option.

PROPOSED ACCESS PLAN

Demand Reduction/Management Strategies

As noted in the Impact Section, the project will have relatively little impact on vehicle or pedestrian traffic due to its small scale, mix of uses and good orientation to public transportation services. Nevertheless, looking at the broader Citywide perspective, reducing the amount of traffic generated is an effective alternative to simply providing the traffic operational improvements necessary to satisfy projected traffic growth. Much can be done to reduce automobile usage and thereby lessen the need for improvements or provide for the more efficient use of any improvements provided. The following describes measures designed to reduce the number of vehicle-trips into the project area. All have been discussed with the proponent, who has committed to implementing them insofar as it is within his ability to do so. He has also agreed to appoint a staff person (construction manager and/or property manager) to work with the City on access plan implementation.

Ridesharing

Ridesharing is an overall term that refers to encouraging commuters to ride in vehicles with other commuters rather than driving to work alone. The most common forms of ridesharing are carpools and vanpools. Increased ridesharing means that fewer vehicles will be using the roadways with the result that there will be less congestion. An additional benefit will be reduced fuel consumption, as fewer vehicle-miles will be traveled.

Carpooling and vanpooling programs are best implemented with a designated coordinator to oversee the program. Incentives will include:

1. Provision of on-site carpool/vanpool matching programs for tenant employees;
2. Participation in joint programs, where available, with other nearby tenants, organizations and companies;

3. Provision of promotional materials on ridesharing to tenants and their employees;

4. Investigation of the feasibility of leasing one or more vans through Caravan or other van leasing programs. The feasibility of a van will be dependent on the nature of the tenants, the location of employees' residences and the employees' hours of work.

Public Transportation

Another way to reduce the number of vehicles on the roadways is to encourage employees to use transit instead of driving to work. The proposed project site is located at the Haymarket rapid transit station (Orange and Green Lines) and is within walking distance of North Station commuter rail, the express bus stop at Haymarket, and the Government Center (Blue and Green Lines) rapid transit station. This provides an excellent opportunity for the project to generate high transit usage. The proponent will encourage further transit usage through the following measures:

1. Provision of an on-site location for sale of MBTA passes and private bus line tickets;

2. Encouraging project tenants to subsidize a portion of their employees' public transportation costs;

3. Have the hotel operator provide courtesy airport limousine/van service to reduce one- or two-occupant taxi or rental car trips.

4. Discuss with the hotel operator the desirability of working with the MBTA on various marketing devices to promote public transportation.

5. The project's property manager will cooperate with the hotel manager on coordinating and promoting public transport strategies.

6. Provision of bus, commuter rail and commuter boat schedules;

7. Provision of promotional and informational materials for all forms of public transportation; and

8. Working with the MBTA to provide a safe and attractive subway portal within the site area to the Orange and Green rapid transit lines. This important access will remain open during construction with no disruption in service during hours of MBTA operation.

Alternative Work Schedules

Alternative work schedules offer a way to reduce peak hour demands on the roadway system and on transit systems by shifting travel to non-peak hour periods or by reducing the total amount of travel per week. The major alternatives are:

1. Staggered Work Hours - are generally set up in such a way that groups of employees are assigned staggered starting times, typically at 15-minute intervals, spread over a one- or two-hour period;

2. Flexible Work Hours - allows employees to choose their own starting and finishing times, as long as they are present during a central part of the day (called core time); and

3. Compressed Work Weeks - involves shifting some workers from a standard five days per week, eight hours per day schedule to fewer days of longer hours (e.g., four days per week, ten hours per day).

The proponent has agreed to the following measures in this category:

1. Encouraging project tenants to implement one of the above concepts during the lease negotiation process;

2. Providing for access to the office building during "off-hours"; and

3. As an incentive for tenants, the proponent will make building services such as heat, air conditioning, etc., available during "off-hours" (up to a fixed number of hours per tenant) at no cost penalty if tenants shift employee start/end times.

Parking Supply Management

The development's all-private parking supply will be managed to encourage reduced peak hour traffic. Measures which would accomplish this include:

1. Provision of up to two vanpool spaces for the project;

2. Preferential parking for carpool and vanpool vehicles (spaces would be assigned at market value to a high-occupancy vehicle in preference to a low-occupancy vehicle);

3. Construction of the project, due to the creation of the through-block connection entrance on New Congress Street, will require the loss of only two or three curb parking spaces on New Congress Street; and

4. One centralized parking garage in/out location on the through-block connector will minize disruptions to traffic flow on the surrounding streets.

Delivery Vehicles

1. Restriction of all office delivery vehicles (with the exception of courier services) to off-peak hours, which include all times other than 7:00-10:00 AM and 3:00-6:00 PM;

2. Restriction of major office deliveries (which typically require the moving of furniture, etc.) to before 7:00 AM or after 6:00 PM;

3. Provision of an office loading dock attendant to encourage off-hours deliveries;

4. Prohibition of any office deliveries by tractor-trailer vehicles;

5. The proponent will encourage the hotel management to participate in this program, although it will be more difficult for a service industry to adhere to the same off-peak schedule; and

6. The office and hotel loading dock locations on Blackstone Street will not require the loss of any curb parking spaces due to the existing parking restrictions.

Taxis

1. Provision of a taxi waiting area on Union Street at the Hanover Street intersection for on-call service to the hotel entrance on Congress Street near Hanover Street. Space for three taxis should be sufficient. Metered curb parking spaces will be lost on Union Street.

2. Taxi drop-offs would occur either on the through-block connection or on New Congress Street.

Pedestrians

Good pedestrian linkages should be available between the project and the main activity areas surrounding the site. Important connections include the following:

- across New Congress Street to Government Center;
- across Sudbury Street to the Government Center Garage, Haymarket buses and North Station area;
- across Blackstone Street to the North End; and
- across Hanover Street toward Quincy Market.

Therefore, the following improvements are proposed to enhance existing pedestrian amenities in the project area:

1. The proponent will provide special paving at all existing crosswalks around the site.

2. All signalized intersections surrounding the site are equipped with pedestrian actuation devices (push buttons) and Walk/Don't Walk signal indications. These have been timed for existing traffic conditions in the area so as to allow concurrent pedestrian crossings and minimize undue delay to both vehicles

and pedestrians. It is proposed that all locations around the site be evaluated by the Boston Transportation Department for potential modifications to pedestrian signal timing and phasing.

3. The intersection of New Chardon Street/North Washington Street/Central Artery off-ramp is lacking pedestrian signals across the north leg of Washington Street. The Boston Transportation Department should install these devices as well as repaint crosswalks at this intersection.

4. Appropriate levels of street lighting will be installed by the proponent on all sidewalks surrounding the site.

5. The proponent will provide brick paving for the existing Congress Street median adjacent to the site.

6. Except for the portion of the site on Blackstone Street at the service driveways, the proponent will provide either a covered arcade or canopy for pedestrians. The arcaded/canopied area will be a public walkway with access to adjacent retail shops.

7. Most of Hanover Street will be repaved in granite by the proponent.

Pushcarts

1. The Haymarket pushcart operation is recognized by the proponent as an important downtown activity. The project has been designed so as to create no long-term impact to this operation. The same space as is presently used on Blackstone and Hanover Streets for this activity will continue to be available.

2. The proponent will endeavor to make some on-site space available for storage of pushcarts. This is currently being discussed with the pushcart association.

Access Goals

1. In the Impact Analysis Section, figures were given for several factors which, when combined, result in the project's relatively small estimated contribution to vehicle-trip and transit-trip loadings on the study area transportation systems. Three such factors are the most significant in terms of this end result. They are:

   - percent transit use (share of person-trips to/from the project by all forms of public transportation),
   - vehicle occupancy rate (average number of people in each vehicle driving to/from the project), and
   - peak hour percentage (the portion of daily trips to/from the project which occur during the AM or PM peak hour)

   To lower vehicular travel even further, it would be desirable if the first two factors were higher than assumed and the third factor lower than assumed. This serves as the basis for establishing a set of access goals for the project, as shown in Table 15. Part A of this table lists each of the three factors, or measures of effectiveness, along with the value estimated in the impact analysis, the Access Plan feature that will try to improve the factor and the goal set for each factor after implementaton of the Access Plan at full project buildout and occupancy. Part B of the table summarizes the AM and PM vehicle-trips and transit person-trips estimated for the original impact analysis factors and for the new factors which will be the goals. It should be noted that all figures in the table refer to office work trips, which constitute about 23 to 32 percent of the project's peak hour vehicle-trip generation and about 47 to 58 percent of its peak hour transit-trip generation. Hotel-related non-work trips constitute most of the project's total travel demand but are not as readily susceptible to demand reduction strategies. However, the proponent has committed to work with the manager ultimately chosen for the hotel portion of the project to attempt to reduce auto travel. Discussions will be held, as previously

noted, on providing courtesy airport limousine/van services and working with the MBTA on marketing increased use of public transportation services. Specific access goals for such measures cannot be identified.

TABLE 15
ACCESS GOALS FOR OFFICE WORK TRIPS

		Analysis Estimate	Mitigation Action	Goal
A. TRIP GENERATING FACTORS				
Percent by Transit		54%	Transit incentives	65%
Vehicle Occupancy Rate		1.5	Ridesharing	1.7
Peak Hour Percentage		55%	Alternative work hours	50%
B. RESULTING PEAK HOUR TRIPS				
Vehicle Trips:	AM	70		39
	PM	70		39
Transit Trips:	AM	157		172
	PM	157		172

2. As a follow-up to the setting of goals, the proponent will endeavor to provide information to the City which can be used to assess actual performance.

3. The proponent also commits to work with the City on a continuing basis to reduce vehicular travel to the site.

Construction Management

An important component of the Access Plan is an effective series of measures designed to minimize traffic flow and safety impacts during the construction phase.

Indicated below are several measures which will be incorporated into the construction management plan for the project. Additional measures may be identified when discussions are held with the contractor selected for the work. The preliminary listing is as follows:

1. Secure fencing, staging and bracing around the entire block, including sidewalks, to protect pedestrian traffic and pushcart operations near the construction site. Access will be maintained to the MBTA subway portal on the site.

2. The project's through-block connection will be provided as soon as feasible during the initial stages of the construction process to serve as a staging area for construction materials (within weight limitations) and as access to other portions of the site. This will minimize disruption to vehicle and pedestrian traffic on surrounding streets and will permit the pushcart operation to continue during construction.

3. No blockage of any existing travel lanes on New Congress, Sudbury, Blackstone or Hanover Streets at any time.

4. Use of a narrow portion of New Congress, Blackstone and/or Hanover Streets (no more than the curb lane) as a materials pick-up area and possibly for placement of a mobile crane. Current activity on these streets precludes travel in the curb lane, minimizing the impact of such activity on through traffic flow.

5. Construction worker parking will not be permitted on any streets. After construction of the project garage, additional space could be available on the site.

6. Scheduling of worker shifts so as to minimze conflict with the typical commuting periods.

Operational Improvements

The project's size characteristics, excellent location with respect to public transportation services, and the proponent's proposed commitment to various demand reduction stragegies all will result in relatively small traffic impacts at the key locations analyzed.

Nevertheless, the proponent recognizes the desirability of improving traffic circulation within the study area so as to maximize efficiency of traffic flow to/from the project site. Therefore, the proponent has committed to work with the City and to support implementation of the following improvement program:

Traffic Operations

Several modifications in traffic operation and control have the potential to improve traffic flow and level of service. These include measures at individual locations to alleviate specific deficiencies at those intersections (under the build condition), specifically the two North Street intersections at Blackstone and New Congress Streets, as well as improvements of a more general nature which would apply to larger street segments or even the entire area. Table 16 summarizes the results, which are discussed below for the North Street intersections.

Intersection-Related Measures. Under 1989 Build conditions, the North Street/Blackstone Street intersection is expected to operate at LOS "F" with V/C ratios of 1.37 and 1.26 in the morning and evening peak hours, respectively. Much of this is due to illegal parking on Blackstone Street in the travel lane adjacent to the median. Intermittent peak hour parking by delivery trucks and vans effectively reduces Blackstone Street to one lane as it approaches North Street. Enforcement of no-parking regulations would improve these V/C ratios to 0.99 and 1.04 in the morning and evening, respectively, while changing the morning level of service to "E" from "F". The evening level of service would remain at "F".

Under 1989 Build conditions, the North Street/Congress Street intersection is expected to operate at LOS "F" in the evening peak hour. The Congress Street approach (southbound) to this intersection currently consists of two travel lanes and a parking lane for City vehicles. The intersection was analyzed to determine if the conversion of the parking lane on the southbound side of New Congress Street to a travel lane would improve operating conditions. In the morning peak hour, there would be a minor improvement in the V/C ratio, however in the evening peak hour, which would be operating at

TABLE 16
COMPARISON OF 1989 BUILD INTERSECTION CAPACITY ANALYSIS BASE CONDITIONS VS. MITIGATION MEASURES

Location	Peak Hour	Base Conditions 1/		Peak Hour Parking Restrictions		After Depressed Artery 2/	
		V/C	LOS	V/C	LOS	V/C	LOS
North Street/ Blackstone Street	AM	1.37	F	0.99	E	0.49	A
	PM	1.26	F	1.04	F	0.57	A
New Congress Street/ North Street	AM	0.83	D	0.81	D	0.83	D
	PM	1.11	F	1.11	F	1.12	F

1/ 1989 Build scenario analyzed previously.

2/ With deletion of Blackstone Street and construction of a new three-lane replacement street.

LOS "F", the V/C ratio would remain unchanged because the critical movements would not be helped by the additional southbound lane.

As discussed earlier, the long-range plan to depress the Central Artery will eliminate Blackstone Street between Sudbury and Hanover Streets. However, a new three-lane local road will be constructed connecting Sudbury Street to North Street. With the site exiting onto this new local street, traffic approaching North Street will travel on three lanes instead of the two lanes (or one with illegal parking) currently provided. The introduction of this local road will improve traffic operations at Blackstone Street/North Street to LOS "A", with V/C ratios of 0.49 and 0.57 in the morning and evening peak hours, respectively. This significant change in level of service is mainly due to the proposed ramp configuration of the depressed Central Artery which would allow direct access to the tunnel without routing traffic through this intersection. Additionally, vehicles traveling to the North End would decrease through this intersection due to other opportunities to access this neighborhood. It should be noted that the project is fully compatible with the proposed design of this area for the Central Artery depression.

System-Related Measures. It has been demonstrated that one of the most effective means available for improving traffic flow on an areawide basis, including central business districts, involve improvements to the traffic signal system.[1/]

It is for this reason that a comprehensive analysis of the existing signal system in the Government Center area is recommended. The existing three-dial fixed-time interconnected system is scheduled to be upgraded to an advanced computer-based system using real-time detection of actual traffic conditions on selected links. The upgraded system can be analyzed for signal timing effectiveness using a computer model such as TRANSYT-7F, which is ideally suited for downtown grid networks. As stated in the previously cited reference, such improvements have

---

1/ Energy Impacts of Urban Transportation Improvements", prepared for the Institute of Transporation Engineers, August, 1980.

been shown to improve speed or travel time in the 8 to 12 percent range, even if the "before" condition involved interconnected pre-timed signals with multiple dials.

Such an analysis may show that a reallocation of green time at study area locations may be beneficial. It may also help in achieving resignalization at the Blackstone Street/North Street intersection, which currently operates in the flashing mode.

Institutional Adjustments

Police Enforcement and Control. With the implementation of the computerized traffic violation program and widespread use of the "Denver Boot" by the Boston Transportation Department, there is an increased awareness on the part of motorists that parking violations are not tolerated by the City nor can they be ignored by the driver. Nevertheless, there is still room for improvement. As demonstrated at the intersections most susceptible to peak hour traffic problems, vigorous enforcement can make available "extra capacity" that is already built into the roadway system, but which goes unused due to illegal parking.

It is proposed that a continuing concentrated effort be made in this regard to insure that more of this capacity is available for peak period use. Increased police visibility and presence in the area, particularly along the most congested portions of Blackstone and North Streets, would be beneficial. Tow-trucks should be readily available to remove violators or for use in emergencies such as breakdowns or accidents in these critical areas. The City's recent announcement with regard to establishment of a traffic control traffic force will be very beneficial in responding to this need.

Goods Delivery. Any consideration of actions to reduce vehicle use in congested areas should encompass all travel, including goods movement, since one significant factor that often contributes to street congestion is delivery/loading activity by commercial vehicles. However, restrictions on truck deliveries are particularly difficult to implement because of the large number of vehicle operators involved. The vast majority of trucks are single-vehicle operations or are from small fleets.

In addition, misdirected restrictions can result in either a decline of commercial activity or an increase in the cost of consumer goods.

Various options are available for restricting Citywide delivery traffic in peak hours, including time shifts, permits, vehicle size limitations, and promotion of fleet efficiency[1/].

Time shifts in delivery schedules may help reduce peak hour traffic conditions. One approach is to structure goods and services traffic to occur before or after the morning rush period. Because the morning rush period is slightly shorter than the afternoon period, the morning period generally has more uncongested time available. Many commercial vehicles already make early deliveries so that this restructuring of delivery times has some acceptance. Another approach is to encourage more night deliveries. In some cases, the installation of "night-drop" facilities (analogous to night mail-drops and bank deposits) can facilitate a shift to night deliveries.

Permits can be issued for commercial vehicles so that only commercial vehicles having a need to be in the congested area in the peak period have legal access to the area. Such permit systems may have to be augmented with truck routes and appropriate signing to divert non-permit commercial vehicles away from or around the congested area.

Vehicle-size restrictions can be imposed. Large trucks and commercial vehicles tend to aggravate traffic congestion during peak periods, but smaller vehicles (such as panel trucks and pickups) have operating characteristics and parking requirements similar to automobiles. Therefore, if the larger vehicles are excluded in specific areas during peak periods, traffic may flow more freely.

[1/] Much of the discussion involving downtown truck deliveries is based on "Actions to Reduce Vehicle Use in Downtown Areas," John Crain et al., Transportation System Management, Transportation Research Board, Special Report 172, 1977.

TECHNICAL APPENDIX

TRAFFIC VOLUMES

The following section includes A.M. and P.M. peak hour turning movement counts conducted during July of 1984 and June of 1986, as well as mechanical recorder counts. The turning movement counts were taken at the intersections of:

- New Chardon Street/North Washington Street
- New Chardon Street/Merrimac Street
- Sudbury Street/New Congress Street/Merrimac Street
- Sudbury Street/Blackstone Street
- North Street/Blackstone Street
- New Congress Street/North Street
- Sudbury Street/Cambridge Street

Mechanical recorder counts were made at the following locations:

- New Sudbury Street - 100 feet west of Blackstone Street
- New Congress Street - 300 feet south of Sudbury Street
- Blackstone Street - 200 feet south of Sudbury Street
- North Street - 50 feet east of Clinton Street

FUTURE TRAVEL DEMANDS

This section includes details about the trip generation and distribution characteristics associated with the proposed project. Included are the following topics:

- Travel Characteristics
  - Person-Trip Generation

- Project Travel Demands
  - Daily Person-Trips
  - Mode of Arrival
  - Peak Hour Travel
  - Vehicle Trips
  - Analysis Condition
  - Truck Traffic

- Background Development
  - Expected Development
  - Travel Demands

- Trip Distribution

Future Travel Demands

To estimate the impact of the proposed project on the transportation system, several sources of information were used. The North Station Urban Renewal Project Draft EIR/EIS, the Marketplace Center EIR, and the Copley Place Draft EIR/EIS were researched to develop modal split, vehicle occupancy and person-trip rates. In addition, an existing Holiday Inn on Cambridge Street in Boston was surveyed to supplement information contained in the referenced material.

Travel Characteristics

Person-Trip Generation. In order to assess the impact of the project on the transportation system, separate travel demand estimates by type of use and users were made.

Table 1 summarizes two-way person-trip rates for office and retail uses per 1,000 square feet of building over the course of the day.

TABLE 1
PERSON-TRIP GENERATION RATES
OFFICE/RETAIL
(Entering and Exiting)

		Daily Person Trips/1000 SF		
Use	User	In	Out	Total
Office	Work	4.4	4.4	8.8
	Non-work	2.5	2.5	5.0
	Total	6.9	6.9	13.8
Retail	Work	2.7	2.7	5.4
	Non-work	15.6	15.6	31.2
	Total	18.3	18.3	36.6

The work-trip rates reflect expected employment density in the proposed project and are typically employee arrival and departure trips. Non-work trips are trips made to and from the project for all other purposes (i.e., shopping, outside business, lunch, etc.).

Table 2 summarizes two-way person-trip rates per hotel room. Each of these tables is independent of mode of arrival.

TABLE 2
PERSON-TRIP GENERATION RATES
HOTEL
(Entering and Exiting)

		Daily Person Trips/Room		
Use	User	In	Out	Total
Hotel	Work	1.00	1.00	2.00
	Non-work	5.94	5.94	11.88
	Total	6.94	6.94	13.88

Table 3 summarizes the mode of arrival characteristics assumed for the project. These percentages appear in the Copley Place, North Station and Marketplace Center reports. The mode split characteristics in Table 3 were applied to the total trip estimates to determine trips by transportation mode.

TABLE 3
MODE SPLIT PERCENTAGES

		Percent Trips By		
Use	User	All Vehicle	All Transit	Walk
Office	Work	36	54	10
	Non-work	45	40	15
Retail	Work	30	60	10
	Non-work	40	20	40
Hotel	Work	12	73	15
	Non-work	60	25	15

Table 4 summarizes anticipated vehicle occupancy rates (VOR) for those trips arriving by vehicle, based on the Copley Place EIS. The average occupancy for hotel work trips is 1.3 persons per vehicle while the non-work trip VOR is 1.4 persons per vehicle.

TABLE 4
VEHICLE OCCUPANCY

Trip Type	Use Hotel	 Office	 Retail
Work	1.3	1.5	1.4
Non-work	1.4	1.3	1.9

Project Travel Demands

Daily Person-Trips. These rates were applied to the total development proposed for Parcel 7. Planned for 1987 are 120,000 square feet of office space, 10,000 square feet of retail space, and 381 hotel rooms as shown in Table 5.

TABLE 5
PARCEL 7 PROJECT DEVELOPMENT

Type Use	Proposed Floor Space 1987
Hotel	381 rooms
Office	120,000 S.F.
Retail	10,000 S.F.

Table 6 summarizes the total daily person trip estimate for the project. A total of 7,311 person trips will be generated over the course of the day, including equal numbers entering and exiting.

Mode of Arrival. Table 7 summarizes the mode of arrival of these trips. Multiplying the trip estimate in Table 6 by the mode split factors in Table 8 results in approximately one-half of the trips accessing the project by a mode other than automobile. Forty-nine percent of the trips to the site are expected by personal auto, carpool, vanpool or taxi while 36 percent are expected by public transportation. The remaining 15 percent are walk

trips. A survey of the Holiday Inn on Cambridge Street in Boston indicated that approximately 35 percent of all vehicle-trips were by taxi. This figure was used in the Parcel 7 analysis.

TABLE 6
PARCEL 7 DAILY PERSON-TRIP ESTIMATE
(Total In and Out)

Use	Trip Type	New Trips 1989
Office	Work	1,056
	Non-work	600
Retail	Work	54
	Non-work	312
Hotel	Work	762
	Non-work	4,527
Total		7,311

TABLE 7
1989 PARCEL 7 DAILY PERSON-TRIPS BY MODE
(Total In and Out)

Use	Trip Type	All Vehicle	All Transit	Walk
Office	Work	380	570	106
	Non-work	270	240	90
Retail	Work	17	32	5
	Non-work	125	62	125
Hotel	Work	91	557	114
	Non-work	2,716	1,132	679
Total		3,599	2,593	1,119
Percent		49.2	35.5	15.3

Peak Hour Trips. Of greater concern than the daily trips is the portion of those trips occurring during the peak commuter hours. It is these peak periods which are used to judge the performance of the transportation system. Table 8 shows the arrival and departure pattern expected during different time periods based on actual survey data. These percentages were based on the Copley Place EIS. However, the percentages for hotel arrivals and departures have been modified to reflect findings of data collected during a survey of the Holiday Inn on Cambridge Street in Boston.

TABLE 8
PERCENTAGES OF DAILY TRIPS DURING PEAK HOURS AND OFF-PEAK HOURS

	Work			Non-work		
Use and Direction	AM Peak	PM Peak	Off-Peak	AM Peak	PM Peak	Off-Peak
Office						
Arrivals	55	0	2	10	0	15
Departures	0	55	2	0	20	15
Retail						
Arrivals	10	10	12	0	5	10
Departures	0	20	12	0	10	10
Hotel						
Arrivals	7	0	5	10	6	8
Departures	0	10	5	4	15	8

Tables 9 and 10 present a summary of future trips anticipated during the morning and afternoon peak periods, respectively. The estimates were derived by multiplying one-half of the daily person trips (to reflect directional travel) by the appropriate factors in Table 8. As can be seen, the peak hour mode of travel is similar to the daily split, with approximately 47 percent by vehicle, 40 percent by transit and 13 percent walk trips.

TABLE 9
1989 PARCEL 7
PERSON-TRIPS BY MODE
AM PEAK HOUR

Use	Trip Type	All Vehicle	All Transit	Walk
Office	Work	104	157	29
	Non-work	14	11	5
Retail	Work	1	2	0
	Non-work	0	0	0
Hotel	Work	3	19	4
	Non-work	190	80	48
Total		312	269	86
Percent		46.8	40.3	12.9

TABLE 10
1989 PARCEL 7
PERSON-TRIPS BY MODE
PM PEAK HOUR

Use	Trip Type	All Vehicle	All Transit	Walk
Office	Work	104	157	29
	Non-work	27	24	9
Retail	Work	3	5	1
	Non-work	9	5	9
Hotel	Work	5	27	6
	Non-work	285	119	71
Total		433	337	125
Percent		48.4	37.6	14.0

Vehicle Trips. By applying the vehicle occupancy rates in Table 4 to the daily and peak hour estimates of person trips by vehicle, the number of vehicle trips to and from the project site can be estimated. These estimates are shown in Table 11. At full development the project will generate 219 and 305 vehicle-trips during the morning and evening peak hour, respectively.

TABLE 11
1989 VEHICLE TRIPS GENERATED BY
PARCEL 7 DEVELOPMENT
TYPICAL WEEKDAY

Use	Trip Type	Daily	AM Peak	PM Peak
Office	Work	253	70	70
	Non-work	208	10	20
Retail	Work	12	1	2
	Non-work	66	0	4
Hotel	Work	70	2	4
	Non-work	1,940	136	203
Total		2,549	219	305

Analysis Condition. The selection of Friday as the base condition for analysis affected the trip generation of hotel guests to the proposed site. It was estimated that 75 to 100 percent of the rooms would be occupied during the weekdays (Monday through Thursday), with approximately 50 percent on weekends (Friday through Sunday). However, on Friday mornings many weekday guests are still checking out. To a lesser degree, there could also be some weekday guests not leaving until Friday evening or Saturday morning. Therefore, to create a conservative but fair condition for analysis, an 80 percent occupancy was assumed for Friday morning and a 60 percent occupancy was assumed for Friday evening. As a result, the actual peak hour vehicle trips analyzed for the hotel non-work component were obtained by applying these factors to the peak hour vehicle trips for hotel non-work trips as shown in Table 11. This results in 0.8 x 136 = 109 AM peak hour vehicle trips and 0.6 x 203 = 122 PM peak hour vehicle trips.

This compares with existing movements into and out of the Parcel 7 parking lot of 60 and 80 during the corresponding peak hours, respectively. Table 11A summarizes total morning and afternoon peak hour vehicle trips for the Friday analysis condition. This condition is more critical than using higher room occupancy rates during midweek, but without the pushcart activity which restricts vehicular capacity on Blackstone Street and eliminates Hanover Street usage completely. Non-vehicular analyses, e.g., pedestrian impacts, were done using the total trip estimates for midweek days (not reduced for the Friday analysis condition).

TABLE 11A
1989 VEHICLE TRIPS GENERATED BY
PARCEL 7 DEVELOPMENT
FRIDAY ANALYSIS CONDITION

Use	Trip Type	Daily	AM Peak	PM Peak
Office	Work	253	70	70
	Non-work	208	10	20
Retail	Work	12	1	2
	Non-work	60	0	4
Hotel	Work	70	2	4
	Non-work	1,358	109	122
Total		1,967	192	222

Truck Traffic. Truck traffic expected to be generated by the Parcel 7 development is summarized in Table 12.

Approximately nine trucks per hour are expected to make deliveries to the complex. If it is assumed that the trucks arrive and depart in the same hour, a maximum of about 18 truck trips per hour will occur. Compared to projected total traffic volumes, this small additional volume would not have a significant impact on the area roadway system.

TABLE 12
PARCEL 7 TRUCK TRAFFIC
(Round Trips)

Use	Truck Generation Rate (per day)	Average Day	Peak[1] Truck Hour
Office	0.21/1,000 S.F.	25	3
Retail	0.24/1,000 S.F.	2	1
Hotel	0.12/room	46	5
Total		73	9

[1] Assumes a constant distribution over a nine-hour day.

One loading dock will be provided off Blackstone Street at the northern corner of the development just south of New Sudbury Street. This dock will primarily serve the office development.

Three docks will be provided for the hotel/retail development on the south side of the project. These loading docks are south of the project access connection, and are also served from Blackstone Street.

Observations of delivery truck activity indicate an average duration of about 15 minutes, or three-to-four trucks per hour per delivery bay. Some smaller trucks are likely to stop at the curb if their delivery time is short. All others are assumed to use the loading docks. Therefore, the four docks provided should be able to accommodate the estimated truck activity generated by the project. Some short-term localized interference with traffic flow on Blackstone Street may develop due to delivery vehicles backing into and out of the loading docks.

Background Development

Expected Development. There are seven other development projects either under construction or in the planning stages in the study area in addition to the proposed Parcel 7 development. The impact of these projects on the transportation system must be considered an integral part of the Parcel 7 development plan. The seven projects are summarized in Table 13.

TABLE 13
STUDY AREA DEVELOPMENT PROJECTS*

Development	Size (square feet)	Type
North Station Urban Renewal Project (GSA Building)	680,000	Office
	20,000	Retail/Comm.
Marketplace Center	296,000	Office
	64,000	Retail
	30,000	Museum
Custom House	223,000	Office
	17,000	Retail
Exchange Place (53 State Street)	1,186,000	Office
75 State Street (formerly 99 State Street)	685,000	Office
	15,000	Retail
Government Center Garage/Office/Retail	249,000	Office
	21,000	Retail
Total	3,319,000	Office
	137,000	Retail/Comm.
	30,000	Museum

* The Auto-Veyor project only consists of parking spaces.

Travel Demands. Vehicle trips generated by the North Station Urban Renewal Project and Marketplace Center have been identified in the respective Environmental Impact Reports filed for each development. In addition, vehicle trips generated by the Government Center Garage Expansion were determined using the same travel characteristics as those assumed for the Parcel 7 development.

Table 14 summarizes vehicle trips generated by these background developments.

TABLE 14
1989 VEHICLE TRIPS GENERATED BY
OTHER NEW DEVELOPMENTS

Development	Daily	AM Peak Hour	PM Peak Hour
North Station Urban Renewal Project (GSA Building)	6,970	1,105	1,181
Marketplace Center	1,660	205	265
Government Center Garage/ Office/Retail	960	137	170
Custom House	634	76	91
Exchange Place (53 State Street)	2,140	751	751
75 State Street (formerly 99 State Street)	1,726	309	317
Auto-Veyor Parking	337	118	105
Total	14,427	2,701	2,880

Trip Distribution

Generated vehicle trips for the Parcel 7 development project and the other background developments were distributed over the available roadway system. Table 15 illustrates the magnitude of the directional distribution. Seventy percent of hotel non-employee trips was assigned to the northeast sector (Logan Airport) and the remaining 30 percent was distributed among the remaining sectors. Retail, office and hotel employee traffic was allocated to districts in proportion to current Downtown Boston travel patterns.

TABLE 15
TRAFFIC ASSIGNMENT BY CORRIDOR

Corridor	All Retail and Office, Hotel Employees	Hotel Non-employees
Northeast	14%	70%
North	14	6
Northwest	9	6
West	17	6
Southwest	22	6
Southeast	24	6
Total	100%	100%

WIND

Pedestrian Wind Visualization and Evaluation

for

RUBIN DEVELOPMENT

C/PA Project

86-0328

June 1986

Prepared by:

CERMAK/PETERKA & ASSOCIATES, INC.
1415 Blue Spruce Drive
Fort Collins, Colorado 80524

Prepared for:

HELLMUTH,OBATA & KASSABAUM
Rockefeller Center
1270 Avenue of the Americas
New York, New York 10020

TABLE OF CONTENTS

Page

LIST OF FIGURES ii

LIST OF TABLES. iii

LIST OF SYMBOLS iv

SECTION

1. INTRODUCTION 1

1.1 The Development. 1
1.2 Urban Wind Characteristics 1
1.3 The Wind Studies 2

2. THE WIND-TUNNEL TEST 3

2.1 Modeling 3
2.2 Experimental Configuration 4

3. DATA ACQUISITION AND RESULTS

3.1 Flow Visualization 6
3.2 Velocity Measurements. 7
3.3 Results and Discussion 8

REFERENCES 14

FIGURES 15

TABLES 109

LIST OF FIGURES

Figure	Description	Page
1a	Wind Engineering Laboratory	15
1b	Closed-Circuit Boundary-Layer Wind Tunnel . . .	16
2	Completed Model in Wind Tunnel.	17
3	Mean Velocity and Turbulence Profiles Approaching the Model and at the Building Site.	24
4	Pedestrian Wind Velocity Measurement Positions	28
5	Zones of High Wind Speeds	35
6	Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations	37
7	Wind Velocity Probabilities for Pedestrian Locations.	86
8	Effective Peak Gusts (mean + 1.5 rms) Wind Speeds Exceeded One Percent of the Time at Measurement Locations for Original Design	107
9	Effective Peak Gusts (mean + 1.5 rms) Wind Speeds Exceeded One Percent of the Time at Measurement Locations for Best Modified Design.	108

LIST OF SYMBOLS

Symbol	Description
U	Local mean velocity
U_R	Mean velocity at reference velocity location at height z_R
D	Characteristic dimension (building height, width, etc.)
ν	Kinematic viscosity
$\frac{UD}{\nu}$	Reynolds number
E	Mean voltage
A, B, C	Constants
U_{rms}	Root-mean-square of fluctuating velocity about mean
E_{rms}	Root-mean-square of fluctuating voltage about mean
z	Height above surface
z_R	Height of reference velocity measurement near upper edge of boundary layer (see Figure 4)
T_u	Turbulence intensity $\frac{U_{rms}}{U_R}$ or $\frac{U_{rms}}{U}$

1. INTRODUCTION

1.1 The Development

The **RUBIN DEVELOPMENT** is a 204 ft, two-tower project located between the Boston City Government buildings and the elevated freeway. The project is adjacent to a historic block to the south, and is bounded by New Sudbury Street on the north, Blackstone Street on the east, Hanover Street on the south, and New Congress Street on the west. The project site is surrounded by lower structures and is exposed to winds from most wind directions. Tall buildings several blocks away provide some protection from winds from the south-southwest through the west.

1.2 Urban Wind Characteristics

The winds blowing over a city are slowed and mixed by interaction with trees, buildings, and other features which contribute to "surface roughness." The result of this interaction is that the average wind speeds increase with elevation above the local terrain up to a level called the gradient height (usually 275 to 400 m, or 900 to 1,350 ft). Above this level, the wind speed is known to be relatively constant and unaffected by the surface development. This region where the surface roughness affects the wind characteristics is known as the atmospheric boundary layer.

High winds at ground level around buildings, such as the towers included in the **RUBIN DEVELOPMENT** design, result from the interaction between the buildings and the higher-speed winds that exist at greater heights. The pressure exerted on the windward face of a building increases with wind velocity, and thus with height, on the building. The pressures will then be greater near the top than near the bottom of the building. As a result of this vertical pressure gradient, high level winds are deflected down the building face from the high pressure to the low pressure region. Winds flowing down the windward face hit the ground and are accelerated around the windward corners by low pressures existing on

the sides of the building. High wind speeds at ground level are most pronounced near tall buildings which are surrounded by structures whose heights are low in comparison to the tall building. Examples of this situation in Boston include the Prudential and John Hancock Towers. At ground level, the highest winds are often found around building corners. This corner flow is usually steady high-speed wind that changes to a lower speed, but gusty, wind as it moves farther from the building. The presence of other nearby buildings can also redirect winds and cause additional increases in wind speed due to funneling or channeling.

1.3 The Wind Studies

The architect has retained CERMAK/PETERKA & ASSOCIATES, INC. to study the potential pedestrian-level wind impacts associated with the new **RUBIN DEVELOPMENT**. The wind-tunnel studies were undertaken in two primary parts. The first part was a flow visualization study in which high wind areas were identified in a qualitative way by smoke visualization. The second part provided quantitative evaluation of wind speeds using hot-film anemometry.

2. THE WIND-TUNNEL TEST

2.1 Modeling

Techniques have been developed in the past two decades for wind-tunnel modeling of proposed structures which allow the prediction of wind velocities and gusts in areas adjacent to a building, wind pressures on cladding and windows, and overall structural loading. Information on sidewalk-level or plaza gustiness allows pedestrian areas to be protected by design changes before the structure is constructed. Possible wind speed reductions near the building can also be quantified. Alternatively, structures with existing design problems can be treated for proposed solutions to optimize the benefit to cost ratio.

Modeling of the wind flow about a structure requires special consideration of flow conditions in order to obtain similitude between the model and the prototype. A detailed discussion of the similarity requirements and their wind-tunnel implementation can be found in References 1, 2, and 3. In general, the requirements are that the model and prototype be geometrically similar, that the approach mean velocity at the model building site have a vertical profile shape similar to the full-scale flow, and the Reynolds number for the model and full scale be equal.

These criteria are satisfied by constructing a scale model of the structure and its surroundings and performing the wind tests in a wind tunnel specifically designed to model atmospheric boundary layer flows. Reynolds number similarity requires that the quantity UD/ν be similar for model and full scale. Since ν, the kinematic viscosity of air, is identical for both, Reynolds numbers cannot be made precisely equal with reasonable wind velocity, a velocity which would introduce unacceptable compressibility effects. However, for sufficiently high Reynolds number ($>2\times10^4$) the pressure coefficient at any location on the structure will be essentially constant for a large range of Reynolds numbers. Typical values encountered are 10^7 - 10^8 for the full scale and 10^5 - 10^6 for the wind-tunnel model. In this range acceptable flow similarity is

achieved without precise Reynolds number equality. All model tests are performed at a sufficiently high velocity to maintain Reynolds number independence.

2.2 Experimental Configuration

The wind-tunnel test was performed in the boundary-layer wind tunnel, which is part of the wind engineering laboratory of CERMAK/PETERKA & ASSOCIATES, INC., Figure 1. This wind tunnel has a 70 ft long test section covered with roughness elements to reproduce at model scale the atmospheric wind characteristics required for the model test. The wind tunnel has a flexible roof, adjustable in height, to maintain a zero pressure gradient along the test section and to minimize blockage effects.

In order to obtain an accurate assessment of local wind velocities, the model was constructed to the largest scale that did not produce significant blockage in the wind-tunnel test section and which provided necessary adjacent buildings on the turntable. The 1:300 scale model was constructed of styrofoam and masonite. Significant variations in the building surfaces were modeled, including arcade undercuts, columns, and canopies.

A circular area 1,500 ft in radius was modeled with significant structures. Structures within the modeled region were made from architectural model materials and cut to the individual building geometries. They were mounted on the turntable in their proper locations. The model was mounted on a turntable (Figures 1 and 2) near the downwind end of the test section. A plan view of the building and its surroundings is shown in Figure 4. The turntable was calibrated to indicate azimuthal orientation to 0.1 degree.

The wind-tunnel floor upstream from the modeled area was covered with roughness elements constructed from small wood blocks. Different sized roughness elements represent different types of roughness upwind of the project site, so that different sets of roughness may be used for different approach wind directions. Spires and a low barrier were installed in the test section entrance to provide a thicker boundary

layer than would otherwise be available, permitting a somewhat larger scale model. The spires, barrier and roughness were designed to provide a modeled atmospheric boundary layer approximately 4 ft thick, a mean velocity power law exponent similar to that expected to occur in the region approaching the modeled area for each wind direction (a number of wind directions may have the same approach roughness), and a turbulence structure in the modeled atmospheric boundary layer similar to that expected in the full-scale wind. The approach wind characteristics used for the model test are shown in Figure 3 and are explained more fully in Section 3.2. Photographs of the model in the wind-tunnel are shown in Figure 2. The wind-tunnel ceiling was adjusted after placement of the model to obtain a zero pressure gradient along the test section.

3. DATA ACQUISITION AND RESULTS

3.1 Flow Visualization

Observing air flow about the model using smoke is helpful in indicating areas where pedestrian winds may be a problem or where wind speed may be low. Titanium dioxide smoke was released from sources on and near the model to make the flow lines visible to the eye and to make it possible to obtain photographic records of the tests. A flow visualization video tape was produced as part of this project showing wind speeds in the areas about the building. The purpose of the flow visualization tests were:

- qualitatively evaluate winds about the project site with and without the project in place,
- qualitatively compare winds about the project site to those in a several block area about the project,
- define high-velocity areas for quantitative evaluation, and
- define locations of more limited wind speeds for quantitative evaluation.

The objectives of the flow visualization study were met by first dividing the model area into investigation zones as shown in Figure 5a. A smoke wand was introduced into each zone for a number of wind directions in order to identify and record the highest wind speed in the zone. The record of wind speeds is shown in Table 4. The table shows the influence of adding the **RUBIN DEVELOPMENT** buildings, and compares the level of windiness between zones. Configuration A represents the existing empty block, and Configuration B is the project as designed prior to any amelioration measures. Examination of the table shows that 1) the influence of the **RUBIN DEVELOPMENT** extends significantly only to surrounding streets, 2) winds are qualitatively increased for some wind directions about the project site, and 3) areas 14 and 15 are significantly windier than the **RUBIN** site based on number of wind

directions in each qualitative wind category. Zones with high wind speeds based on qualitative indications are shown graphically in Figure 5.

On the basis of the flow visualization study, minor changes in locations for quantitative measurements were made to move locations to positions with high wind speed indications. The resulting locations for quantitative wind measurement are shown in Figure 4a.

Photographs of flow near various locations about the project site are shown in Figure 2. These photographs are discussed in Section 3.3 along with the quantitative measurements. A videotape also shows similar flow visualization where smoke motion is observable.

3.2 Velocity

Vertical profiles of mean velocity and longitudinal turbulence intensity were measured upstream of the model to determine that an approach boundary layer flow appropriate to the site had been established. Tests were made at one wind velocity in the tunnel. This velocity was well above that required to produce Reynolds number similarity between the model and the prototype as discussed in Section 2.1.

The surface measurements are indicative of the wind environment to which a pedestrian at the measurement location would be subjected. The locations were chosen to determine the degree of pedestrian comfort, or discomfort, at the building corners where relatively severe conditions frequently are found, near building entrances and on adjacent sidewalks where pedestrian traffic is heavy, and in open areas.

Measurements were made with a single hot-film anemometer which was mounted with its axis vertical. The instrumentation used was a TSI, Inc. constant temperature anemometer (Model 1053b) with a 0.002 inch diameter platinum film sensing element. Output was directed to the on-line data acquisition system for analysis.

Calibration of the hot-film anemometer was performed by comparing it to the output of a commercially calibrated flow meter. The calibration data were fit to a variable exponent King's Law relationship of the form

$$E^2 = A + BU^C$$

where E is the hot-film output voltage, U the velocity and A, B and C are coefficients selected to fit the data. The above relationship was used to determine the mean velocity at measurement points using the measured mean voltage. The fluctuating velocity in the form U_{rms} (root-mean-square velocity) was obtained from

$$U_{rms} = \frac{2\ E\ E_{rms}}{B\ C\ U^{c-1}}$$

where E_{rms} is the root-mean-square (about the mean) voltage output from the anemometer. For interpretation, all turbulence measurements for pedestrian winds were divided by the mean velocity U_R at the reference velocity location near the upper edge of the boundary layer. Turbulence intensity in velocity profile measurements used the local mean velocity.

3.3 Results and Discussion

Mean velocity and turbulence intensity profiles for the boundary layer flow approaching the model and at the building site are shown in Figure 3. Profiles were taken upstream from the model which are characteristic of the boundary layer approaching the model. All model velocities were referenced to a velocity at 875, 900, or 1,200 ft as is shown in Figure 3. The mean velocity profile approaching the modeled area has the form

$$\frac{U}{U_R} = \left[\frac{z}{z_R}\right]^n$$

in which U is the mean velocity at height z, U_R is a reference wind speed at reference height z_R at which the Pitot-static probe was mounted in the wind tunnel, and n is a constant which depends on the characteristics of the upstream roughness. The exponent n for the approach flow established for this study for each of three approach range of directions is shown in Figure 3. The three approach wind characteristics were due to different roughness characteristics of the upwind fetch which change the structure

of the approach boundary layer. The values of $n = 0.15$, 0.17, and 0.25 were characteristic of the approach surface roughnesses represented by land and water near the site. The profiles do not precisely fit the selected power law exponent curve since the wind-tunnel upwind roughness varies upwind of the turntable in approximately the same form as the full-scale roughness. Thus, the approach profile measured just upwind of the modeled turntable area reflects the variable roughness upwind. Mean velocity profiles measured at the building site, shown in Figure 4, reflect the influence of surrounding buildings and freeway.

Profiles of longitudinal turbulence intensity in the flow approaching the modeled area and at the building site are shown in Figure 3. The turbulence intensities are appropriate for the approach mean velocity profiles selected. For the velocity profiles, turbulence intensity is defined as the root-mean-square about the mean of the longitudinal velocity fluctuations divided by the local mean velocity U:

$$T_u = \frac{U_{rms}}{U}$$

Velocity data obtained at each of the pedestrian measurement locations shown in Figure 4 are listed in Table 1 as mean velocity U/U_R, turbulence intensity U_{rms}/U_R, and as the largest effective gust

$$U_{pk} = \frac{U + 3U_{rms}}{U_R}$$

The mean and peak velocities obtained 5 to 7 ft above ground level are plotted in polar form in Figure 6. The graphs show velocity magnitude and the approach wind direction for which that velocity was measured. The polar plots aid in visualization of the effects of the nearby structures on the velocity and turbulence magnitudes.

To enable a quantitative assessment of the wind environment, the wind-tunnel data were combined with wind frequency and direction information obtained at Logan International Airport. Appendix A provides a discussion of the Boston wind climate including a rationale for the wind climate selected for use. These data, obtained at an elevation of 22 ft, were combined statistically with the wind-tunnel data of Table 1 to obtain

cumulative probability distributions of wind speed for the full-scale site at each pedestrian measurement location. The distributions are plotted in Figure 7. These curves show for each pedestrian location the percent of time that a given mean velocity or effective peak velocity is exceeded at that location. Because pedestrians will tolerate higher wind speeds for a smaller period of time than for lower wind speeds for longer duration, these curves provide a means of evaluating the overall acceptability of a pedestrian location.

Interpretation of Figure 7 is aided by a description of the effects of wind of various magnitudes on people. The earliest quantitative description of wind effects was established by Sir Francis Beaufort in 1806 for use at sea and is still in use today. Several recent investigators have added to the knowledge of wind effects on pedestrians. These investigations along with suggested criteria for acceptance have been summarized by Penwarden and Wise [4] and Melbourne [5]. The Beaufort scale from Reference 4 is based on mean velocity only and is reproduced in Table 3 including qualitative descriptions of wind effects. Table 3 suggests that mean wind speeds below 12 mph are of minor concern and that mean wind speeds above 24 mph are definitely inconvenient. Quantitative criteria for acceptance from Reference 5 are superimposed as dashed lines in Figure 7. The peak gust curves shown in Figure 7 are the percent of time during which a short gust of the stated magnitude could occur (say about one of these gusts per hour).

The overall indications of pedestrian wind comfort are well described in Figure 7, in particular the percent time exceeded plots which show the effective gust (mean plus 3 x rms). The mean velocity percent time exceeded plots are useful, but may present too severe a comparison to acceptance criteria because of conservative assumptions about anticipated turbulence intensities which were incorporated into the mean velocity acceptance criteria. Conclusions drawn from the gust graphs on the right in each part of Figure 7 indicate that, in Configuration A without the **RUBIN DEVELOPMENT**, locations 14, 35, and 40 are windier than other areas and are of some concern for pedestrian acceptability—particularly location 40 which should be considered unacceptable. All three of these

locations are away from the project site. All other locations fall within a velocity range typical of urban environments.

In Configuration B, with the **RUBIN** project in place, Figure 7 shows high wind velocities at the same three locations (essentially unchanged) and somewhat elevated wind speeds at locations 1 and 8. Locations 1 and 8 are indicative of a marginal wind climate, but are not at the unacceptable level. Locations 6, 11, and 24 reach significant velocities for less common winds (one percent level) but are within the range of typical urban winds for 90 to 95 percent of the time.

Configurations C through F represent various changes in the model as described in Table 2 and Figure 4. Configuration C repeated some measurements of Configuration A without the **RUBIN DEVELOPMENT** to determine the influence of changes in the garage structure to the north, not incorporated in the Configuration A. Configuration D incorporated the first amelioration measures to try to reduce wind speeds at locations 1, 6, and 8. These changes incorporated an arcade at location 1 (adding point 40 under the arcade), more extensive canopies near location 6, and changes in columns, signage and other details near location 8. In addition, trees were added to Curly Park to the south and across New Congress Street to the west of location 8—these trees are in existence. Configuration E was the second amelioration trial, and incorporated a canopy at location 1, but no arcade, and added sidewalk planters near location 8. A rooftop location was added in Configuration E to determine conditions there. Configuration F added height to two of the planters of Configuration E. The planters of Configurations E and F near location 8 are unrealistically large, but were included to show the extent of local blockage necessary to provide a major reduction in wind speed at location 8.

Results of amelioration Configurations D, E, and F in Figure 7 indicate that at location 1, the arcade of Configuration D improved conditions slightly, but the canopy of Configuration E worked better reducing the winds to a reasonable level for an urban environment. At location 8, minor changes in wind speed were noted until unrealistically large planters were introduced which did significantly reduce wind speeds. Location 42 near location 8 was included to show winds under the over-

hang—winds were lower than at location 8. At location 6, little change was observed form increasing the canopy extent. At location 43 on the lowrise roof, added for Configuration E, wind speeds were similar to those at location 1 without amelioration measures: somewhat windier than desirable for a pedestrian sidewalk environment where walking is the prime function, and unacceptably windy for leisure activities such as dining.

The City of Boston has specific informal guidelines for pedestrian wind environment acceptability. These guidelines, established by the Boston Redevelopment Authority (BRA), limit effective wind gusts (defined as the mean plus 1.5 rms) to 31 mph for winds exceeded 1 percent of the time. A table of these values is shown in Table 5. For information, the mean velocity exceeded 1 percent of the time is shown in Table 6. The various configurations are defined in Table 2. Table 5 shows that in Configuration A without the **RUBIN DEVELOPMENT**, locations 14, 35, and 40 exceeded the informal criteria. In Configuration B, locations 1 and 8 are added to the list exceeding the guidelines, although only by 1 mph at location 8. These locations are at the north and south corners of the new building complex.

Modifications of Configuration D included an arcade near location 1 with location 41 in the arcade, and additional columns near location 8 with location 42 under the overhang. Although location 6 did not require amelioration, additional canopies were added to try to reduce winds at that location. The arcade at location 1 decreased the wind gust from 35 to 33 mph at location 1, but did not provide a pedestrian path at location 41 below the guideline level. At location 6 no change in gust magnitude was observed. At location 8, the gust magnitude decreased from 32 to 31 mph fitting within the BRA informal guideline.

Modifications for Configuration E involved canopies but no arcade at location 1, and the addition of large planters, 8 ft in diameter and 3 ft high, at location 8. While location 8 was shown to be acceptable in Configuration D, an indication of the required surface treatment near location 8 to reduce wind speeds was desired. Table 5 shows that the effective gust at location 1 was reduced to 31 mph, within BRA informal

guidelines. Winds at location 8 were 32 mph, essentially unchanged with the addition of planters which completely block the sidewalk. At location 43, added on the lowrise roof for this configuration, a gust value of 35 mph was recorded, above the BRA guideline and well above the level that would be acceptable for leisure activities. Further amelioration measures were not requested for this site; however, it can be anticipated that extensive architectural treatment would be required to bring the wind speeds down to a leisure activity acceptance level.

A final Configuration F increased the height of planters adjacent to location 8 to 6 ft (5 ft did not provide a wind speed reduction). The gust value decreased to 20 mph. This experiment effectively showed that sidewalk treatment with planters cannot practically be used to reduce winds at location 8 below 31 mph.

Figure 8 shows the gust velocities for Configurations A and B. Locations above the informal guidelines in either configuration are shown as triangles to emphasize these locations. Figure 9 shows the gust velocities of the best geometry in comparison to the gust winds of Configuration A in the same format.

The results of the wind-tunnel test showed that all ground level locations about the **RUBIN DEVELOPMENT** can be brought to or below the BRA informal guidelines with proper architectural treatment: canopies near location 1 and column treatment near location 8. The one location measured on the lowrise roof showed wind speeds above the BRA guideline. This location should not be considered for pedestrian use without extensive architectural treatment of that area.

REFERENCES

1. Cermak, J.E., "Laboratory Simulation of the Atmospheric Boundary Layer," AIAA Jl., Vol. 9, September 1971.

2. Cermak, J.E., "Applications of Fluid Mechanics to Wind Engineering," A Freeman Scholar Lecture, ASME Jl. of Fluids Engineering, Vol. 97, No. 1, March 1975.

3. Cermak, J.E., "Aerodynamics of Buildings," Annual Review of Fluid Mechanics, Vol. 8, 1976, pp. 75-106.

4. Penwarden, A. D. and Wise, A.F.E., "Wind Environment Around Buildings," Building Research Establishment Report, HMSO, 1975.

5. Melbourne, W. H., "Criteria for Environmental Wind Conditions," Jl. Industrial Aerodynamics, Vol 3, 1978, pp. 241-247.

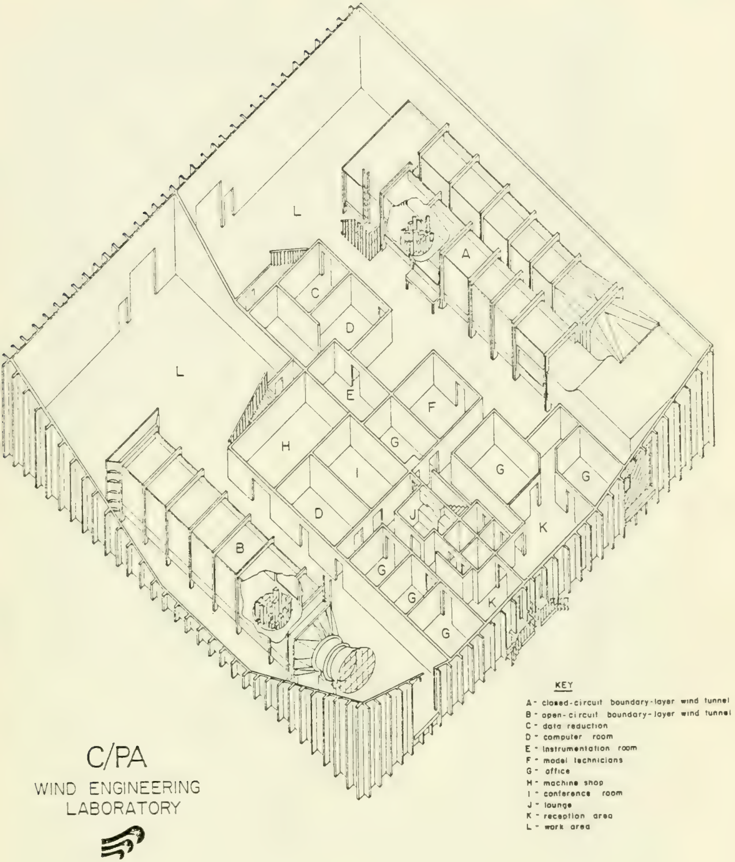
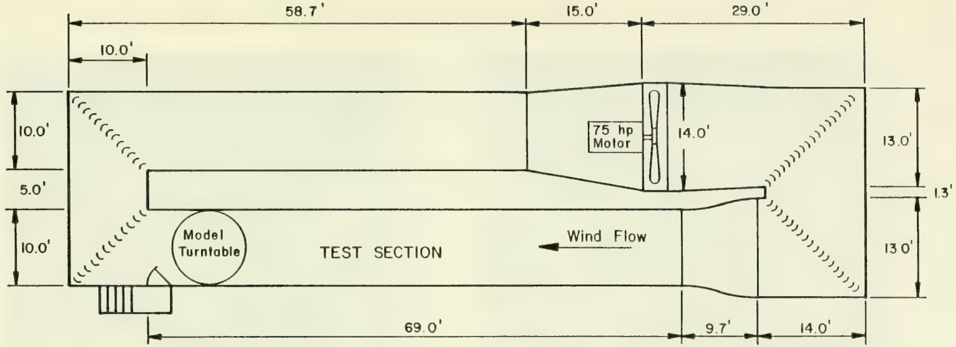
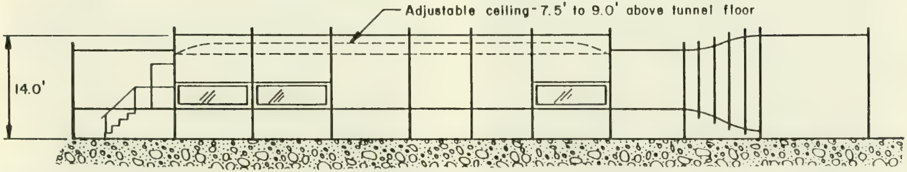


Figure 1a Wind Engineering Laboratory

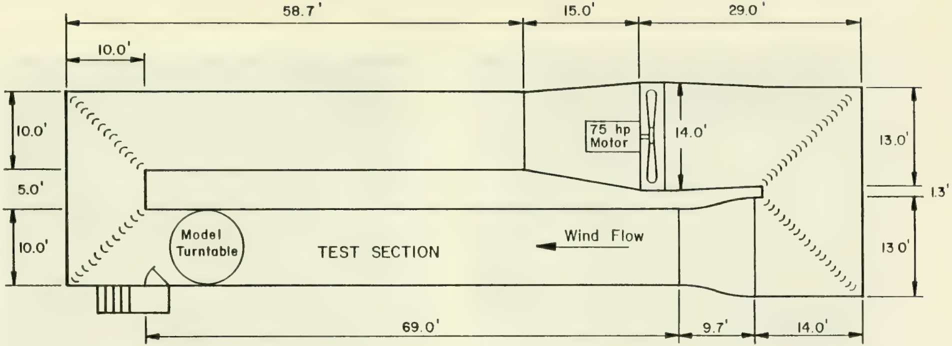


Plan View

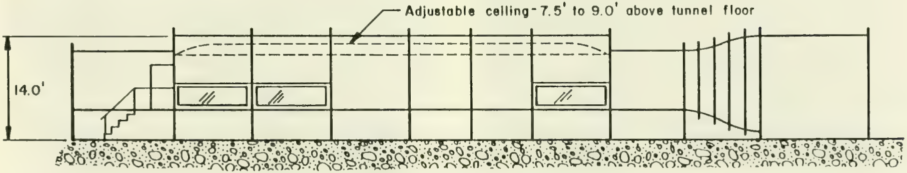


Elevation View

Figure 1b Closed-circuit Boundary-layer Wind Tunnel

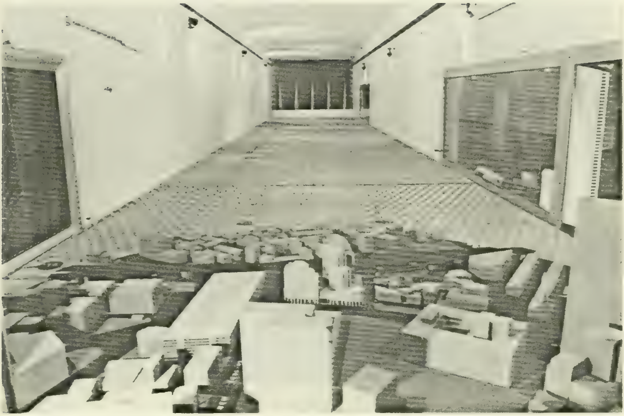


Plan View

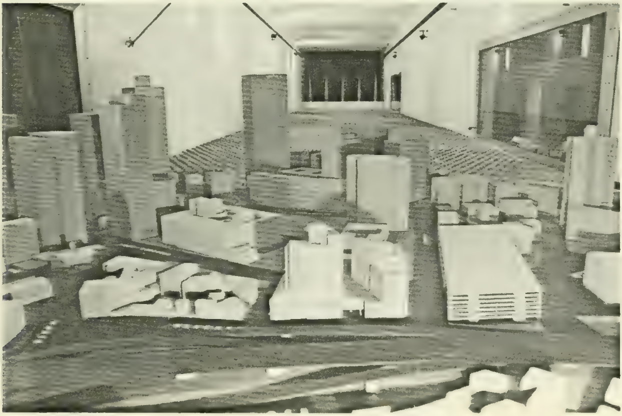


Elevation View

Figure 1b Closed-circuit Boundary-layer Wind Tunnel

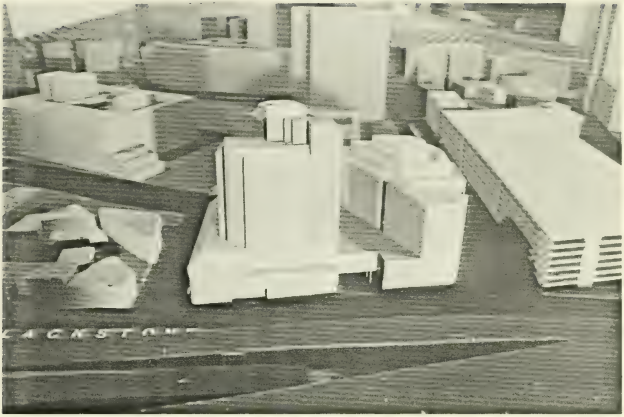


a. Configuration B



b. Configuration B

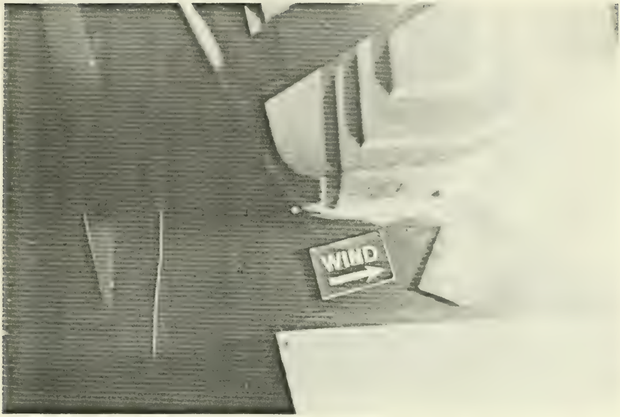
Figure 2 Completed Model in the Wind Tunnel



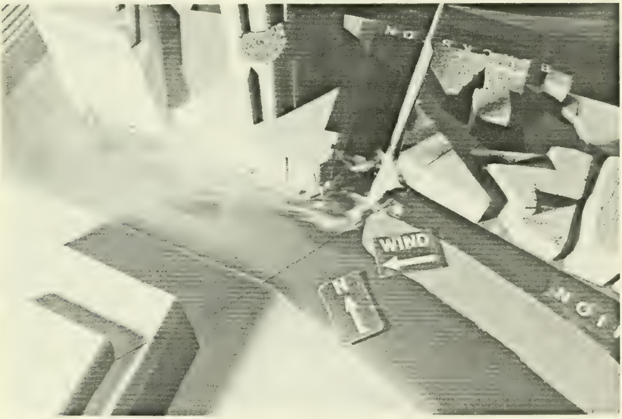
c. Configuration B

d. Configuration B

Figure 2 Completed Model in the Wind Tunnel

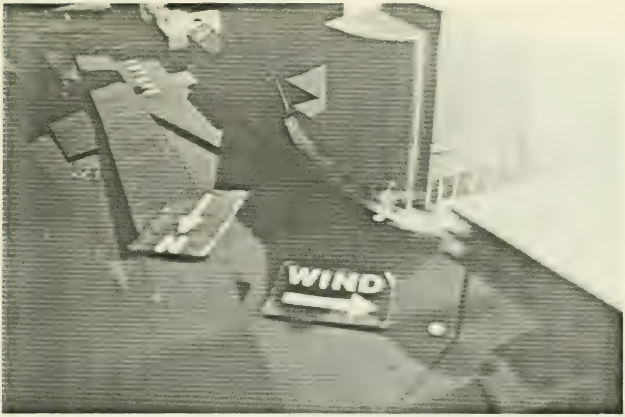


e. Winds at Location 1 in Configuration B

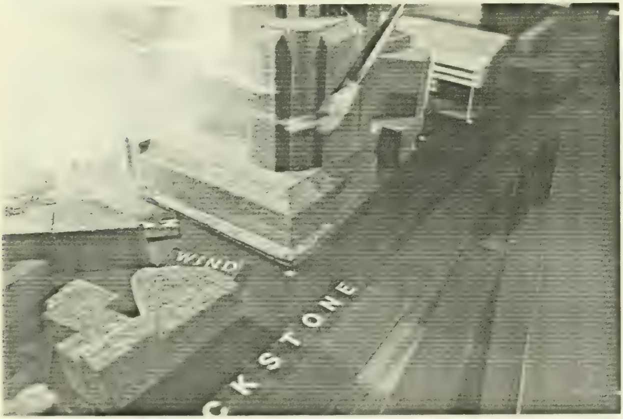


f. Winds at Location 8 in Configuration B

Figure 2 Completed Model in the Wind Tunnel

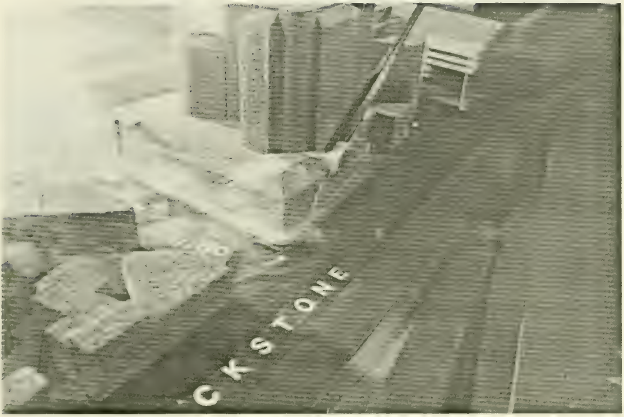


g. Winds at Location 1, Configuration D, Amelioration Trial 1

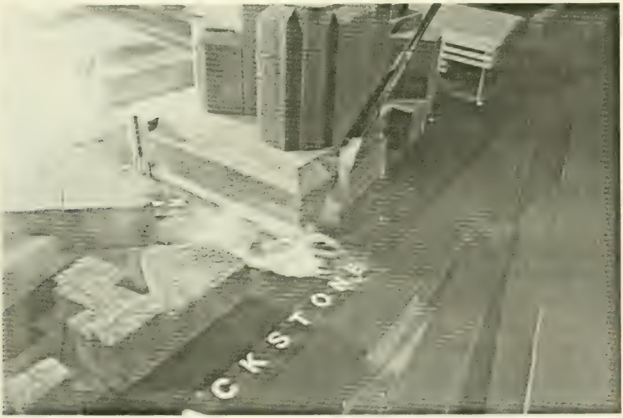


h. Winds Above Location 6, Configuration D, Amelioration Trial 1

Figure 2 Completed Model in the Wind Tunnel

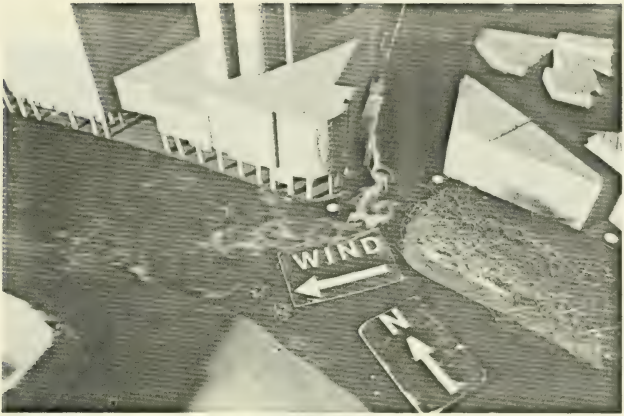


i. Winds at Locaton 6, Configuration D, Amelioration Trial 1

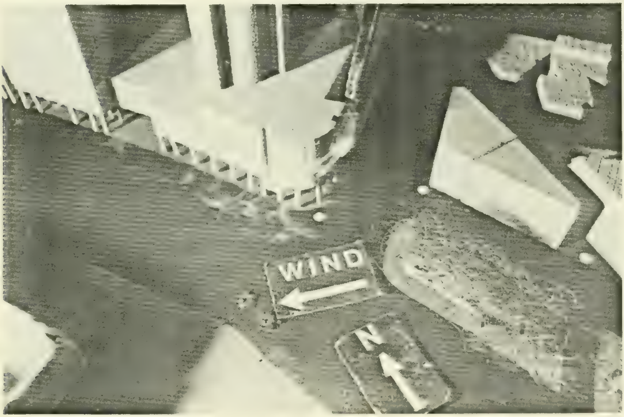


j. Winds at Location 8, Configuration D, Amelioration Trial 1

Figure 2 Completed Model in the Wind Tunnel

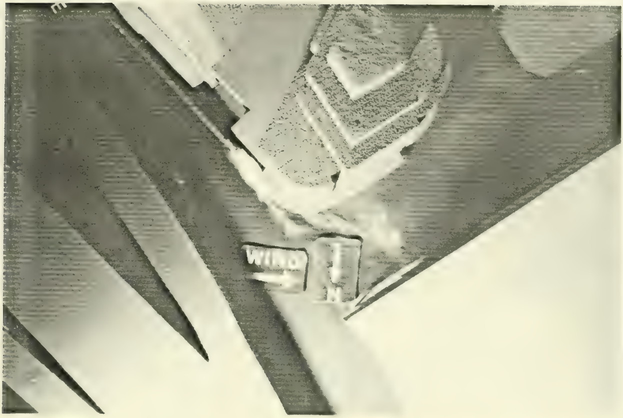


k. Winds at Location 8, Configuration D, Amelioration Trial 1

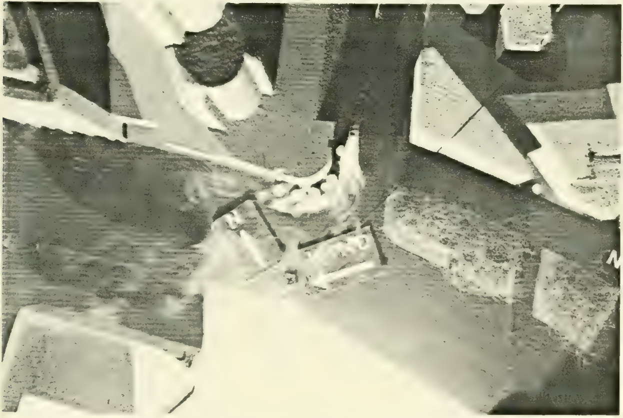


l. Winds at Location 8, Configuration D, Amelioration Trial 1

Figure 2 Completed Model in the Wind Tunnel



m. Winds at Location 1, Configuration E, Amelioration Trial 2



n. Winds at Location 8, Configuration F, Amelioration Trial 3

Figure 2 Completed Model in the Wind Tunnel

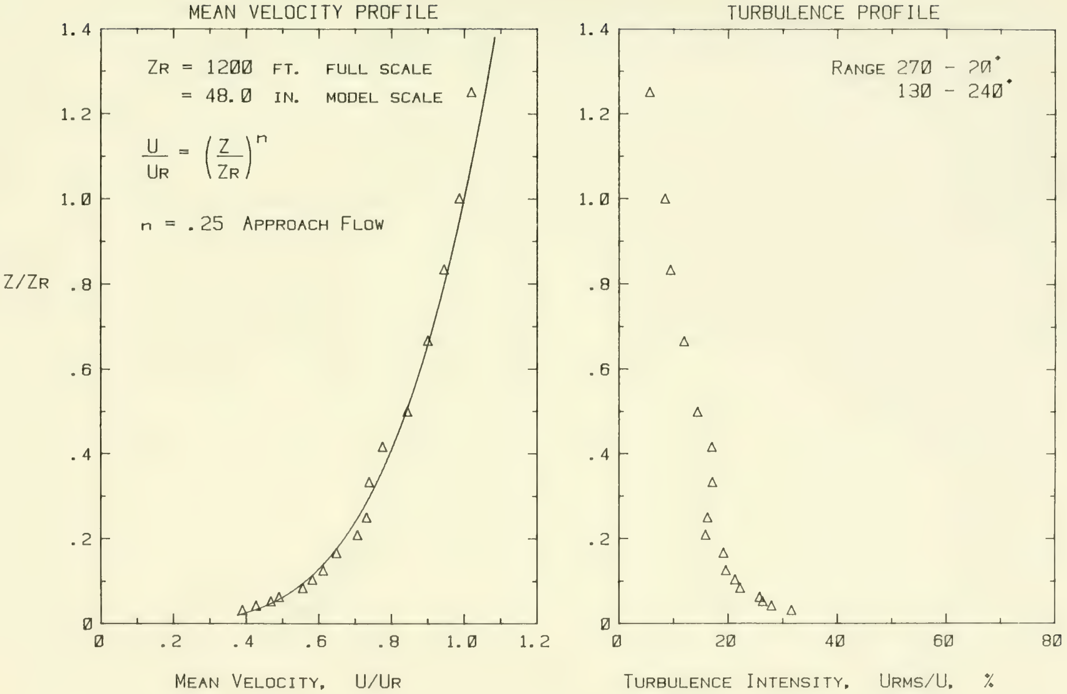


Figure 3a Mean Velocity and Turbulence Profiles Approaching the Model and at the Building Site

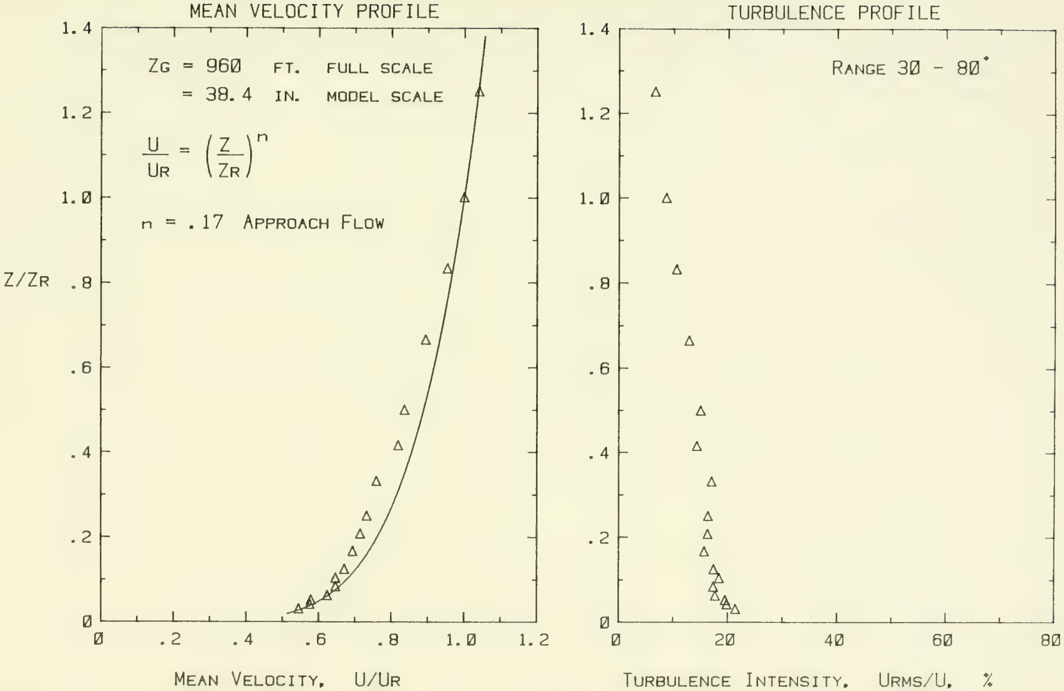


Figure 3b Mean Velocity and Turbulence Profiles Approaching the Model and at the Building Site

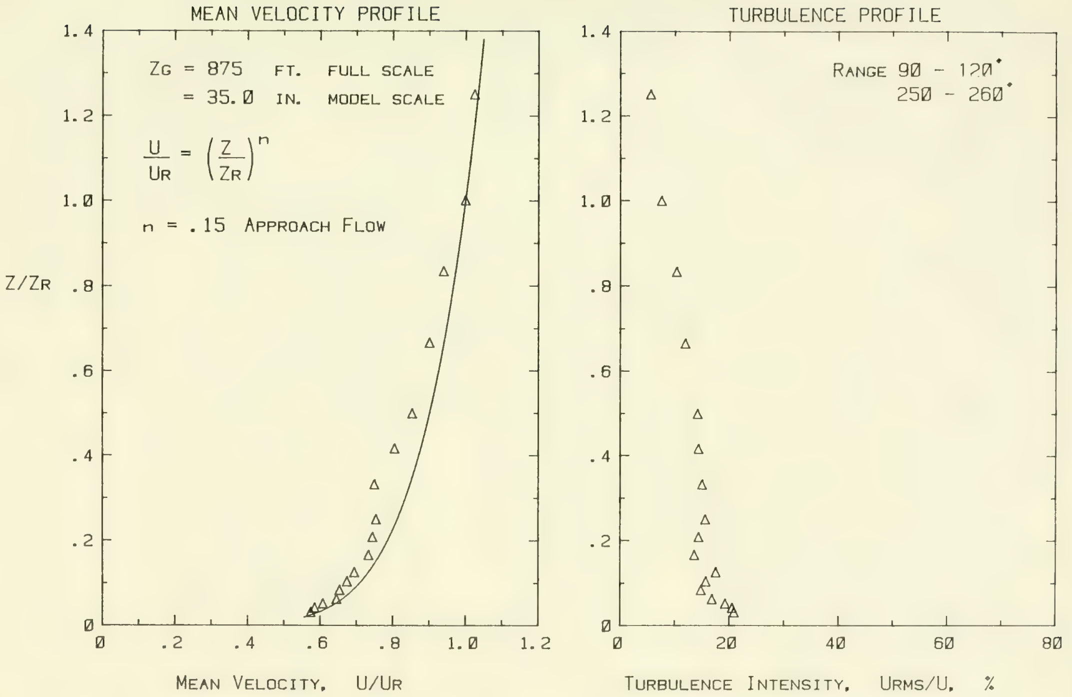


Figure 3c Mean Velocity and Turbulence Profiles Approaching the Model and at the Building Site

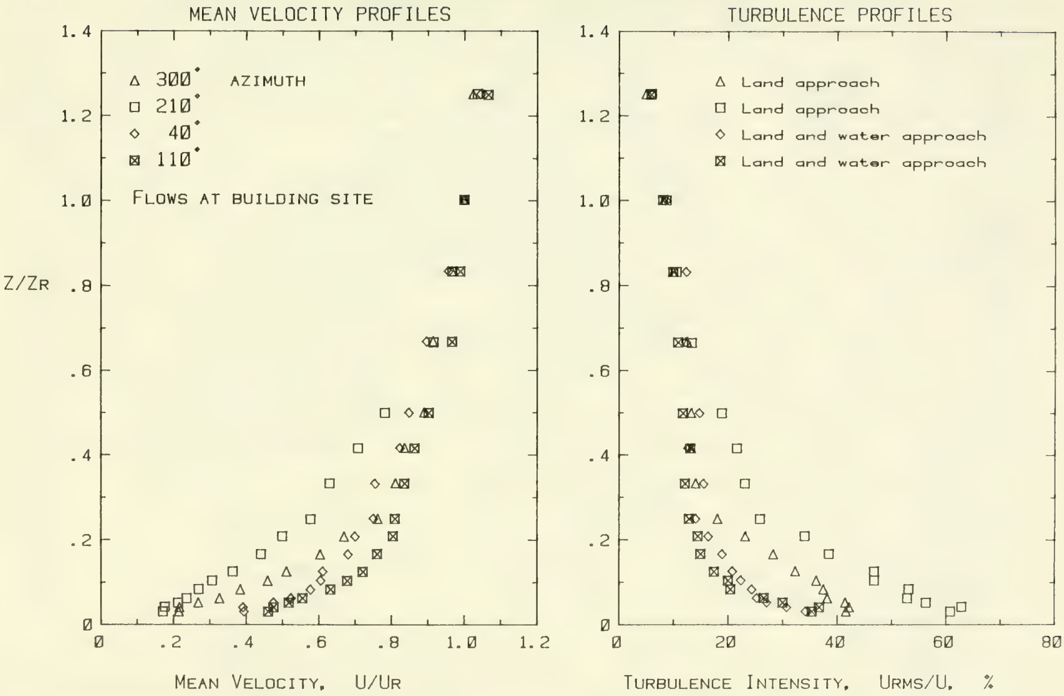


Figure 3d Mean Velocity and Turbulence Profiles Approaching the Model and at the Building Site

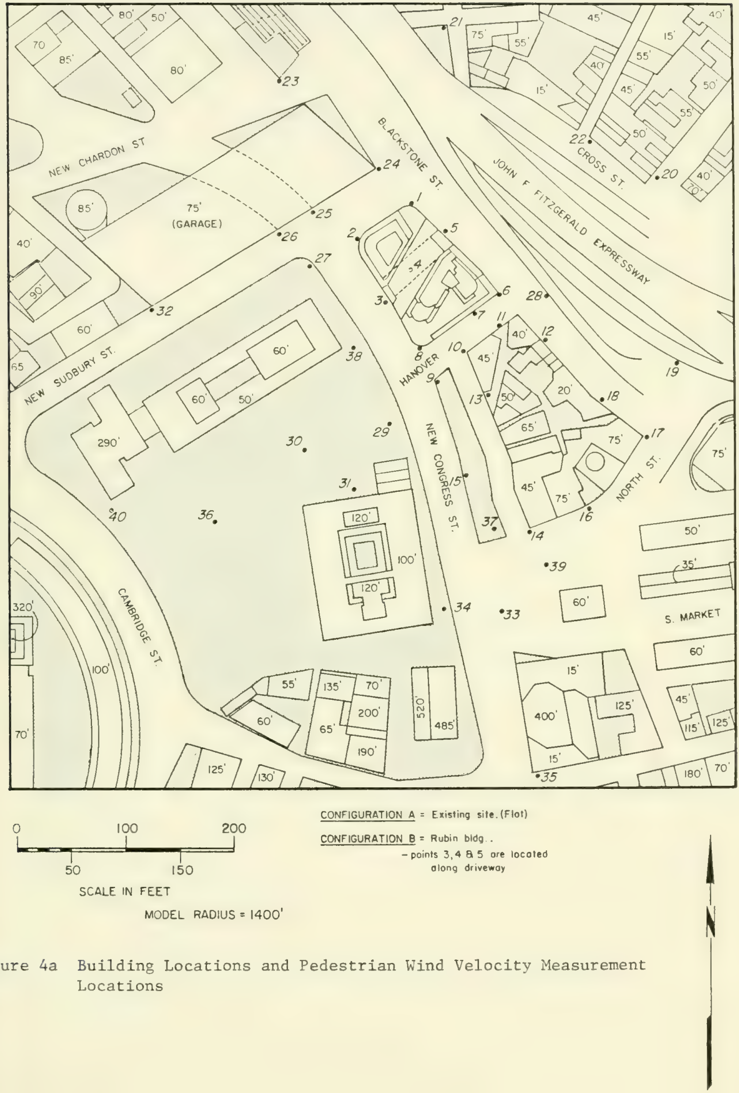
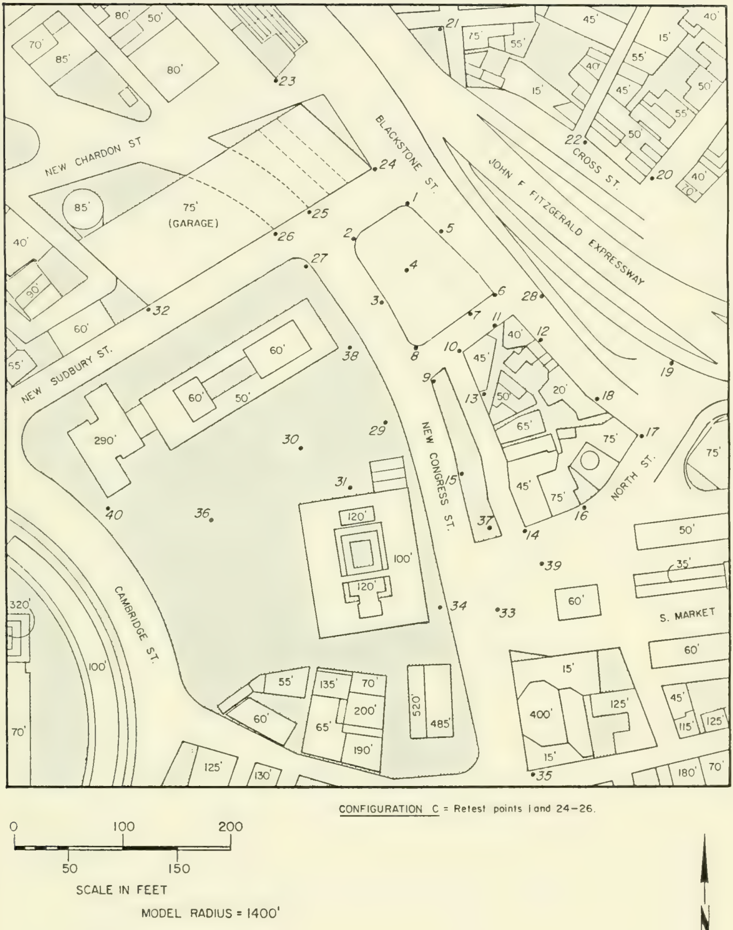
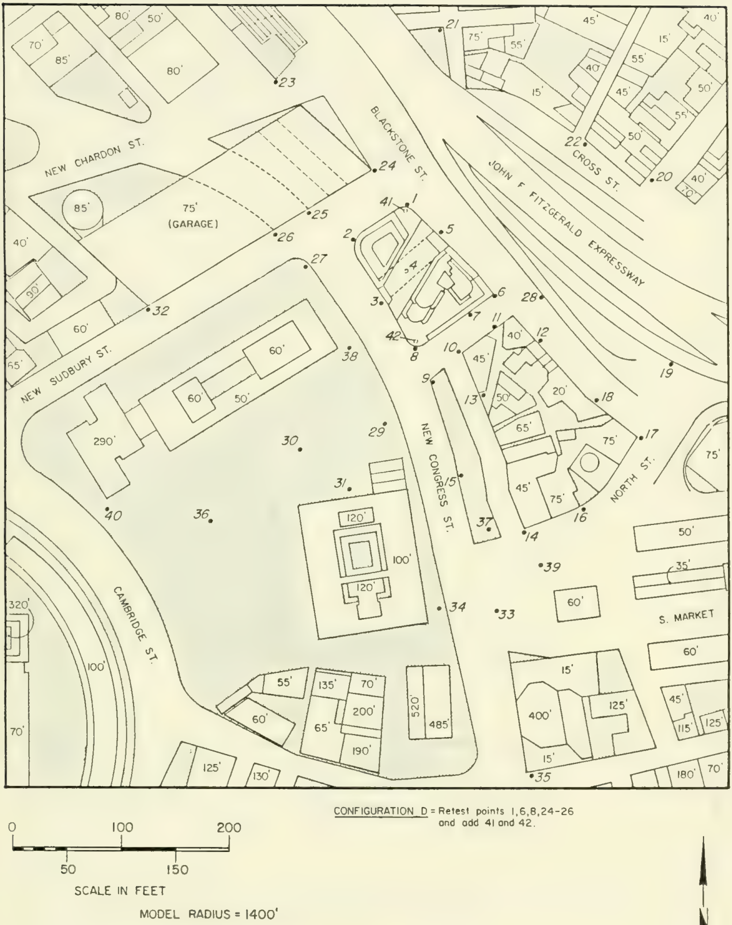


Figure 4a Building Locations and Pedestrian Wind Velocity Measurement Locations



CONFIGURATION C = Retest points 1 and 24–26.

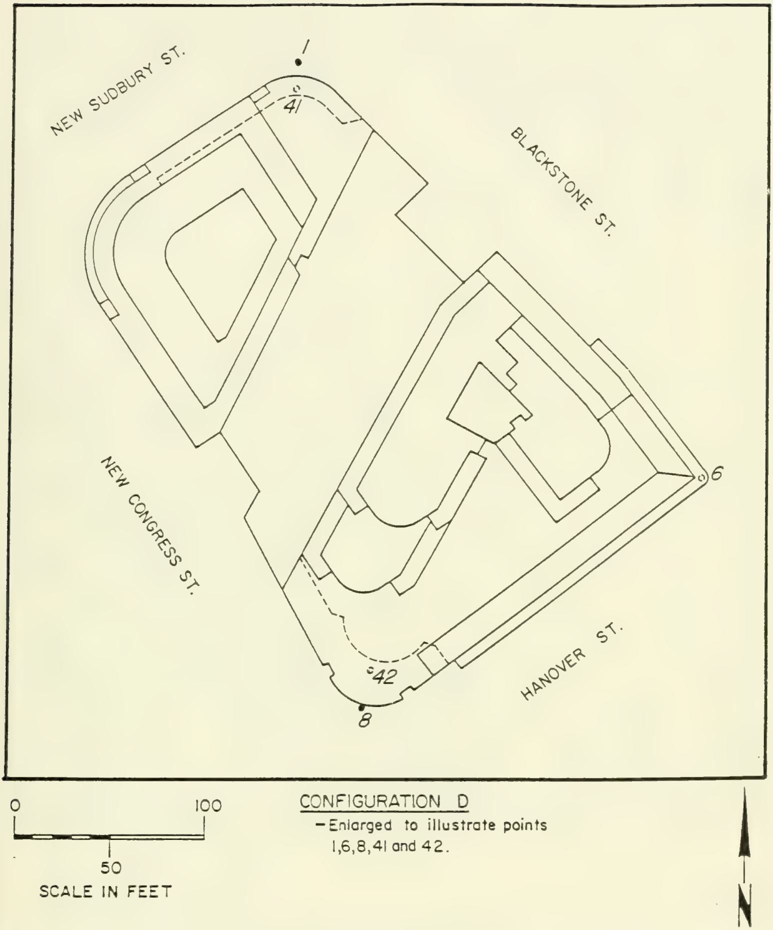
Figure 4b Building Location and Pedestrian Wind Velocity Measurement Locations



CONFIGURATION D = Retest points 1,6,8,24-26 and add 41 and 42.

MODEL RADIUS = 1400'

Figure 4c Building Location and Pedestrian Wind Velocity Measurement Locations



CONFIGURATION D

—Enlarged to illustrate points 1,6,8,41 and 42.

Figure 4d Building Location and Pedestrian Wind Velocity Measurement Locations

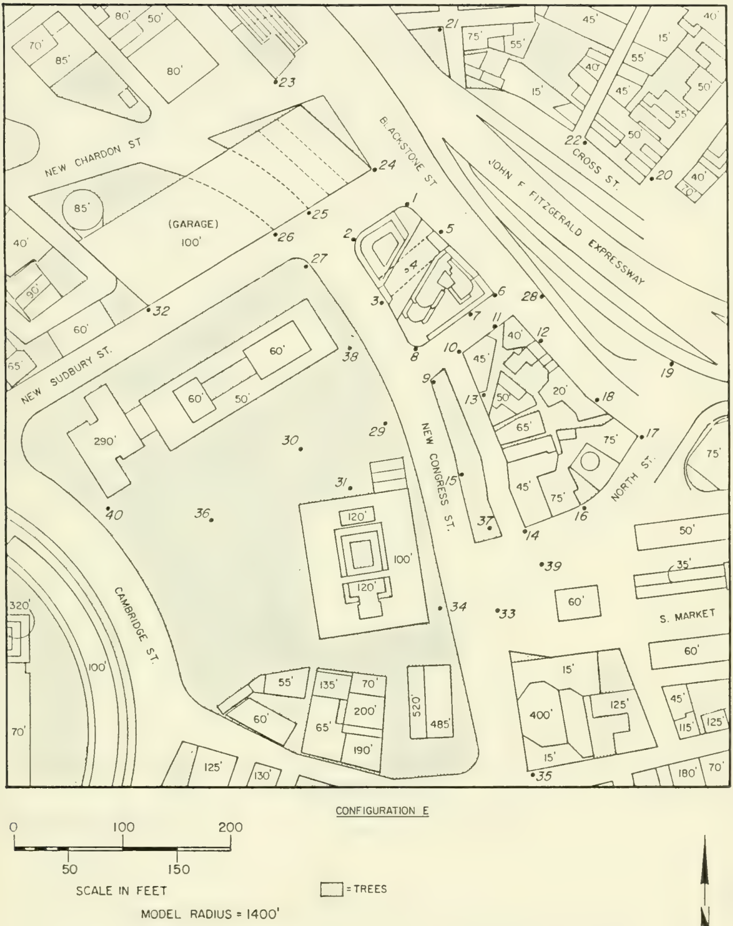
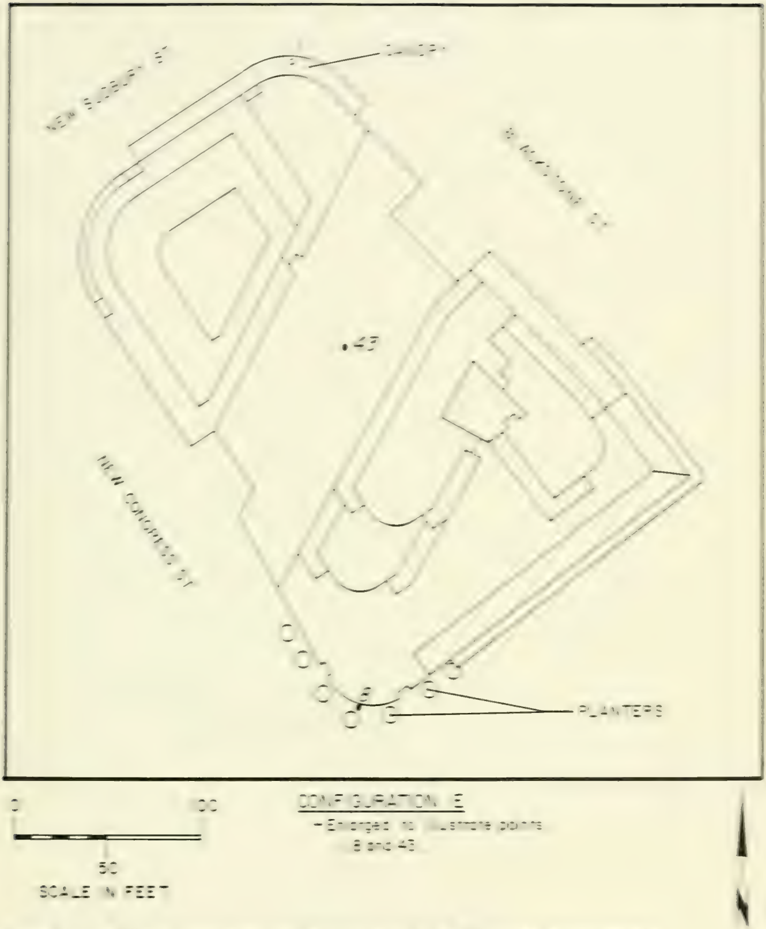


Figure 4e Building Location and Pedestrian Wind Velocity Measurement Locations



CONFIGURATION E

* Enlarged to illustrate points 8 and 43

Figure [illegible] Building Location and Pedestrian Wind Velocity Measurement Locations

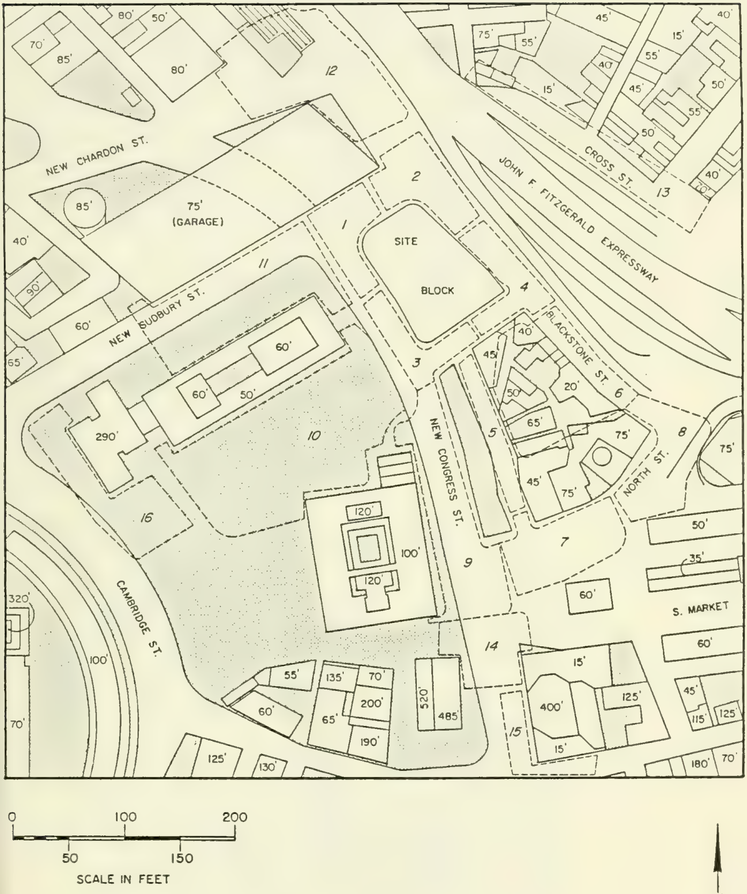
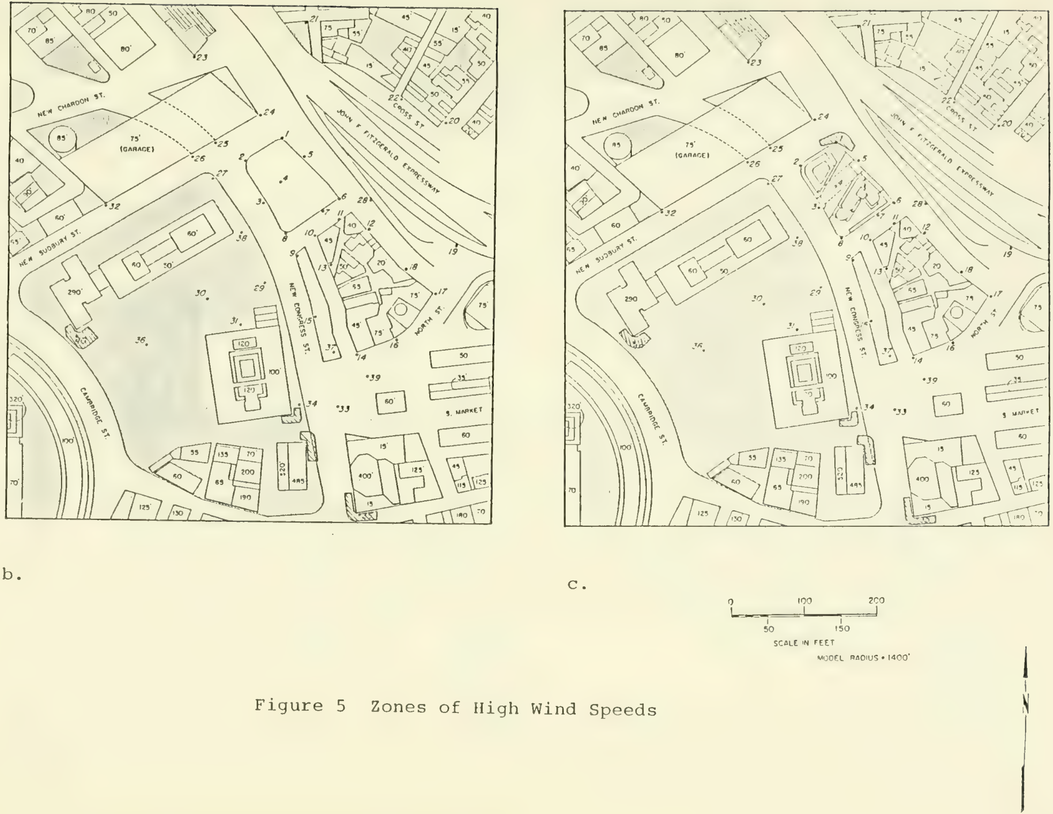


Figure 5a Zones of High Wind Speeds



b.

c.

Figure 5 Zones of High Wind Speeds

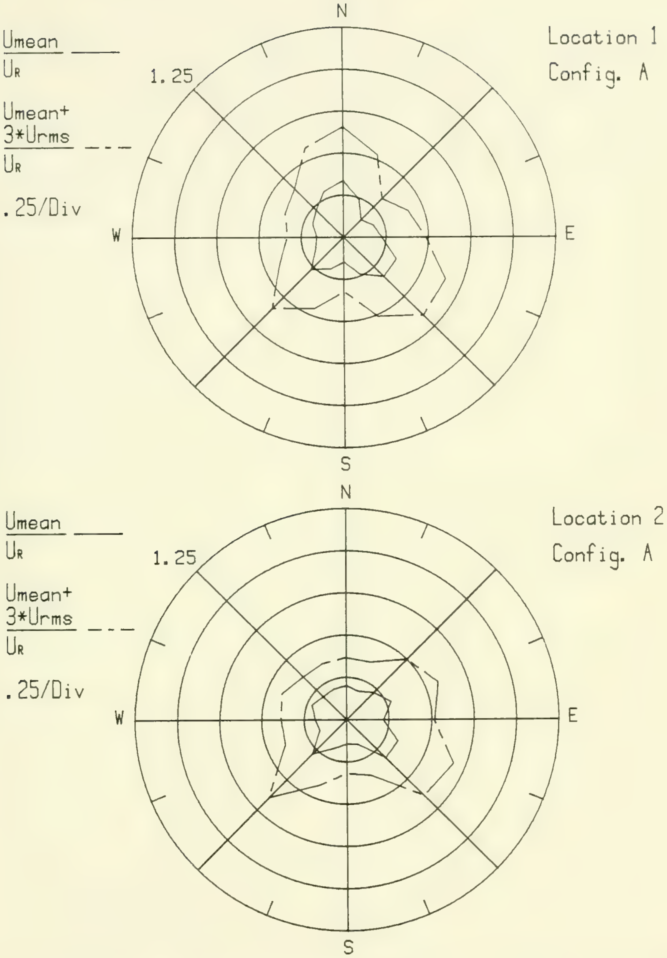


Figure 6a Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

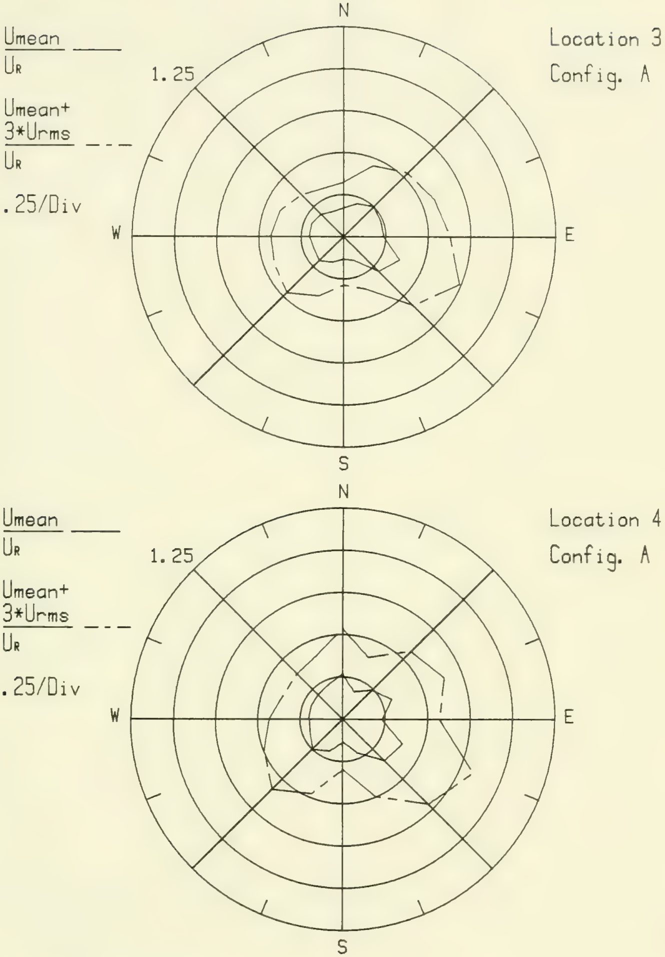


Figure 6b Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

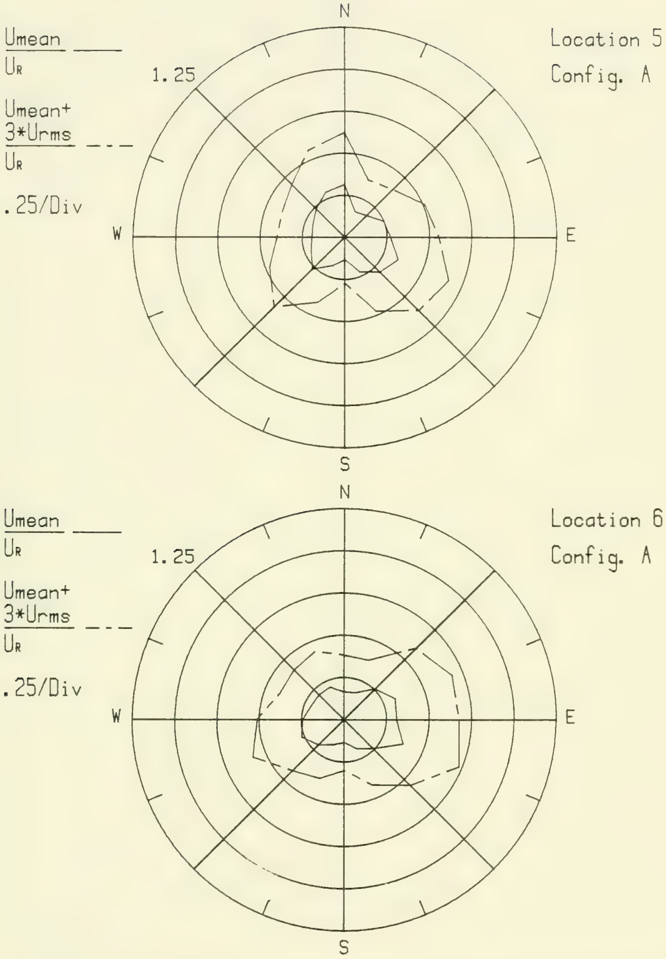
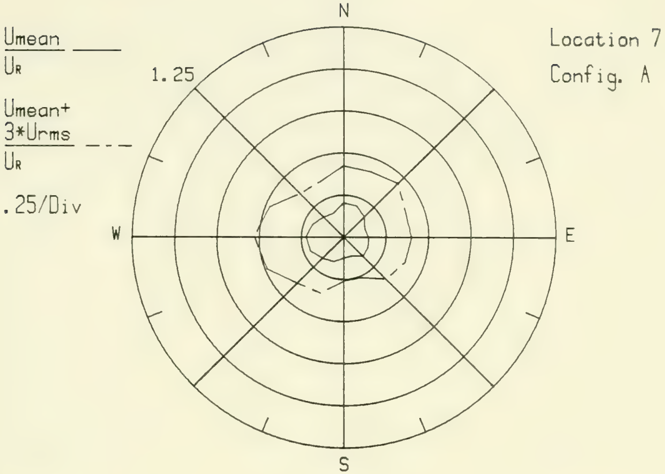


Figure 6c Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations



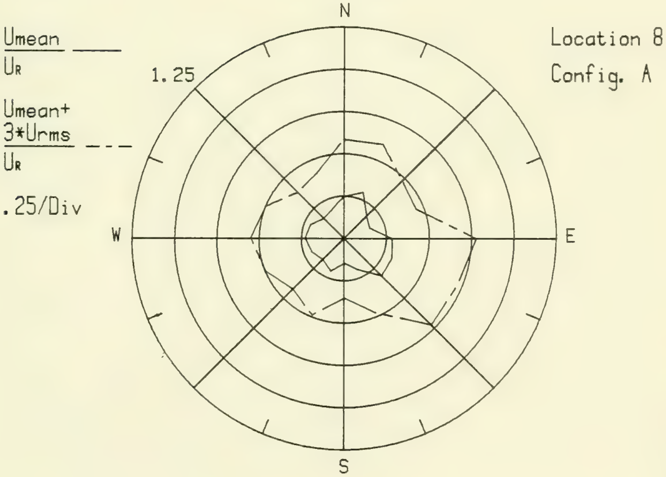


Figure 6c Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

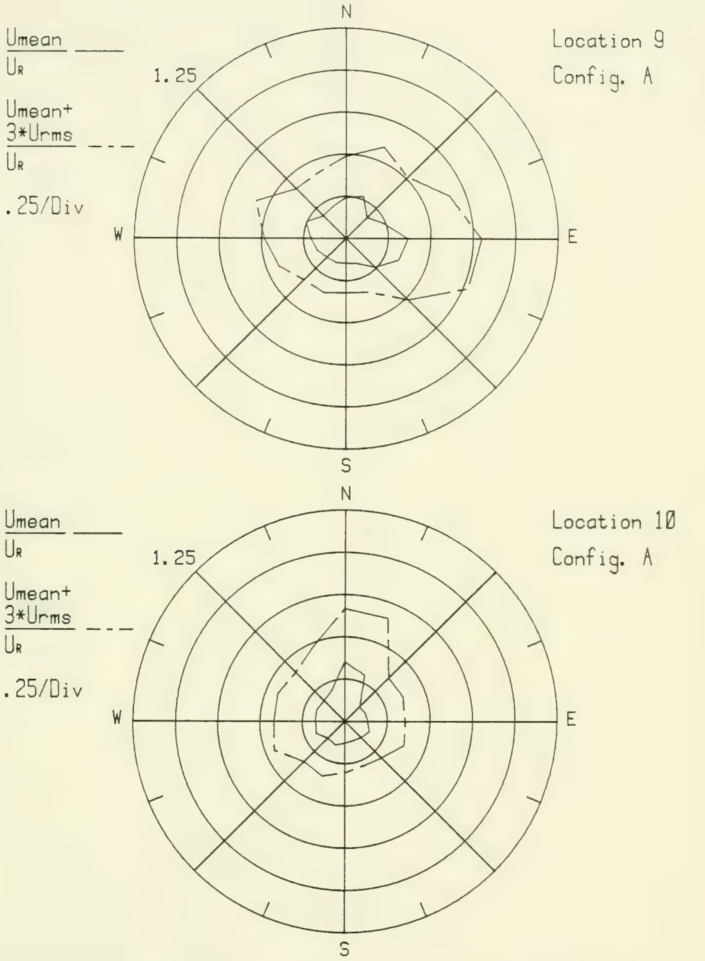


Figure 6e Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

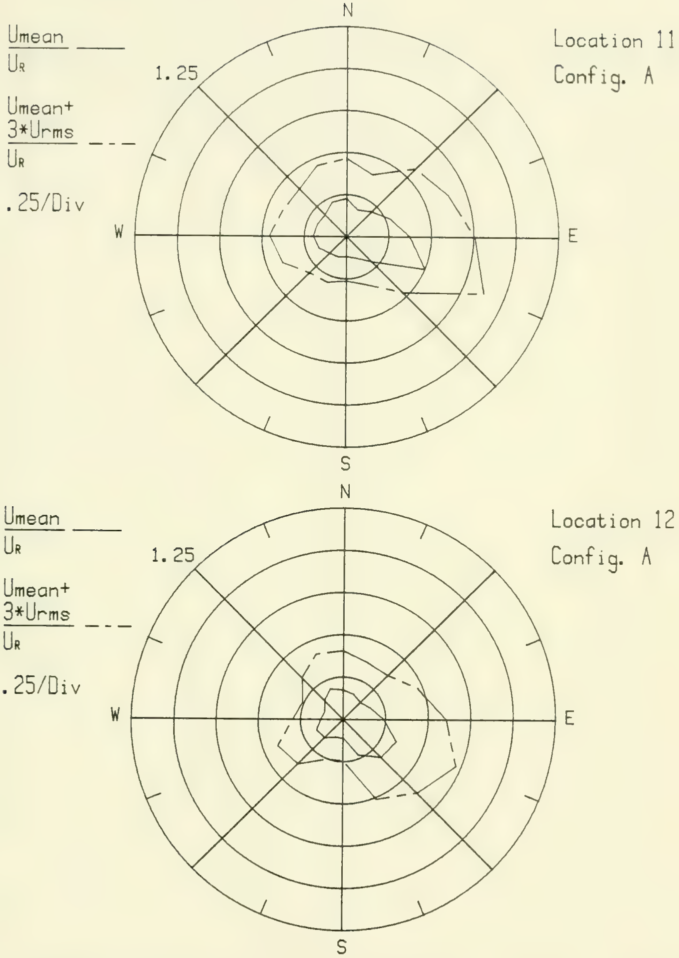


Figure 6f Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

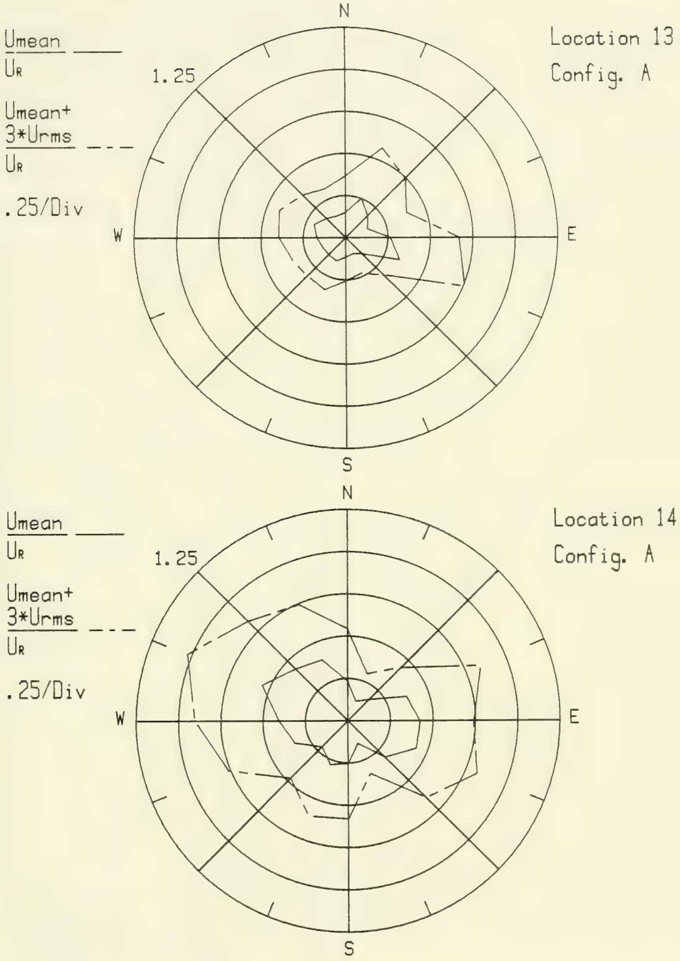


Figure 6g Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

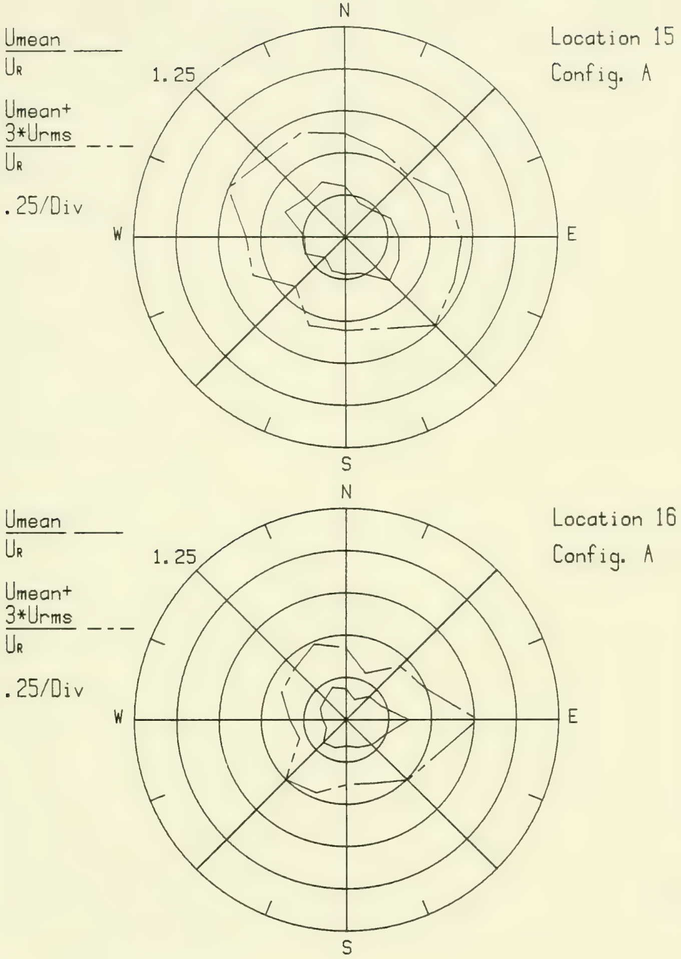


Figure 6h Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

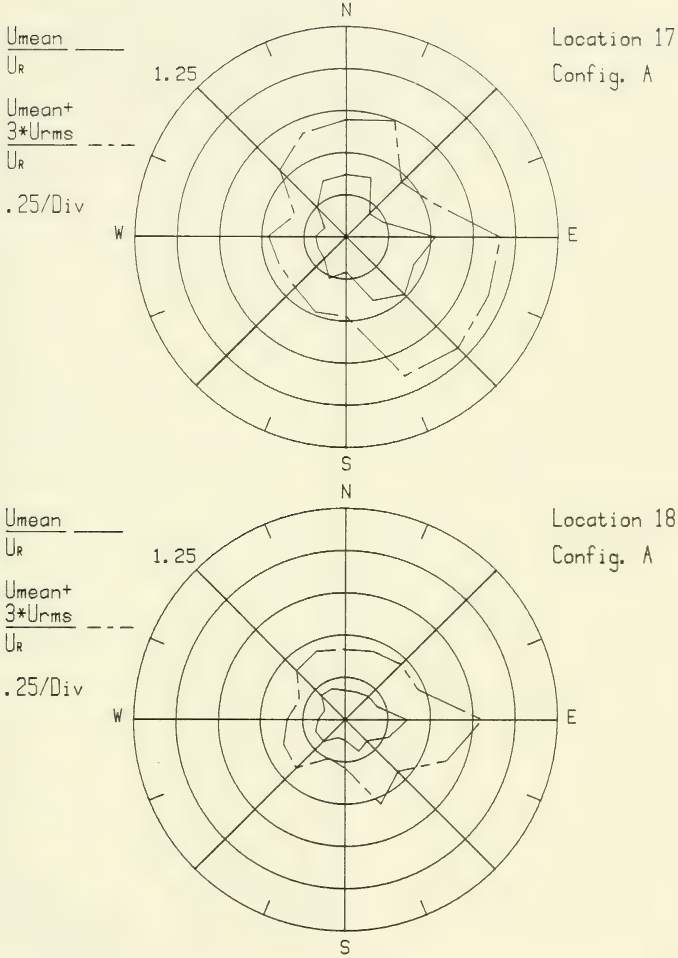


Figure 6i Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

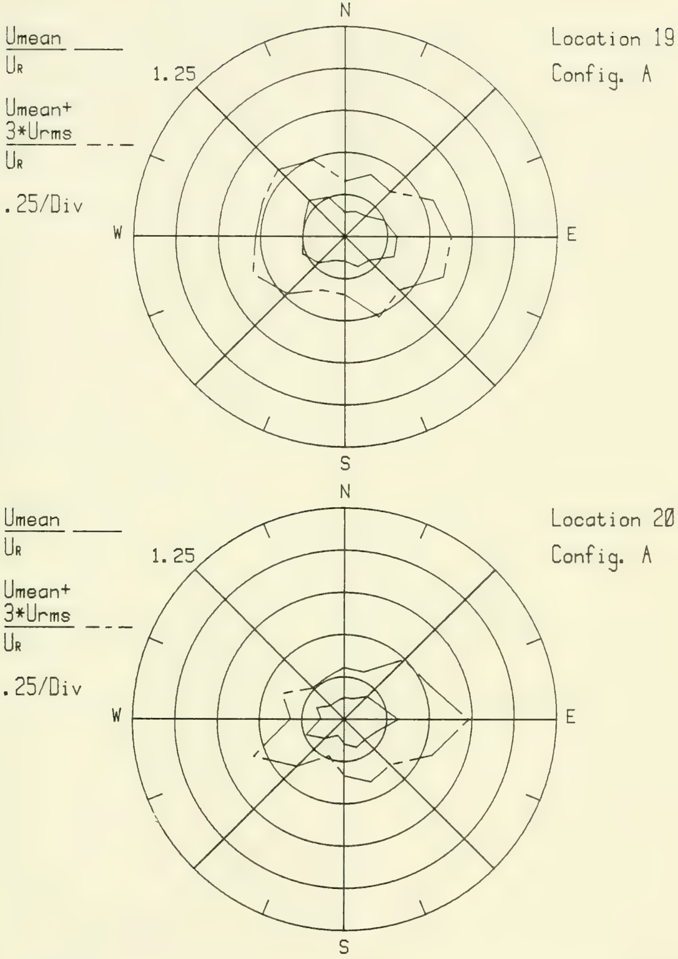


Figure 6j Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

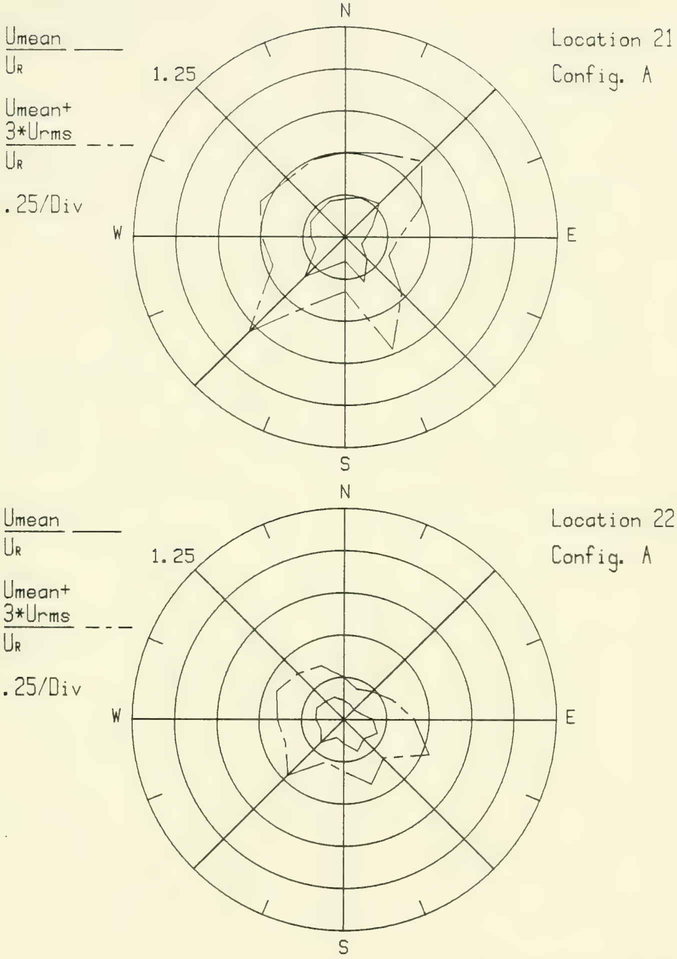


Figure 6k Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

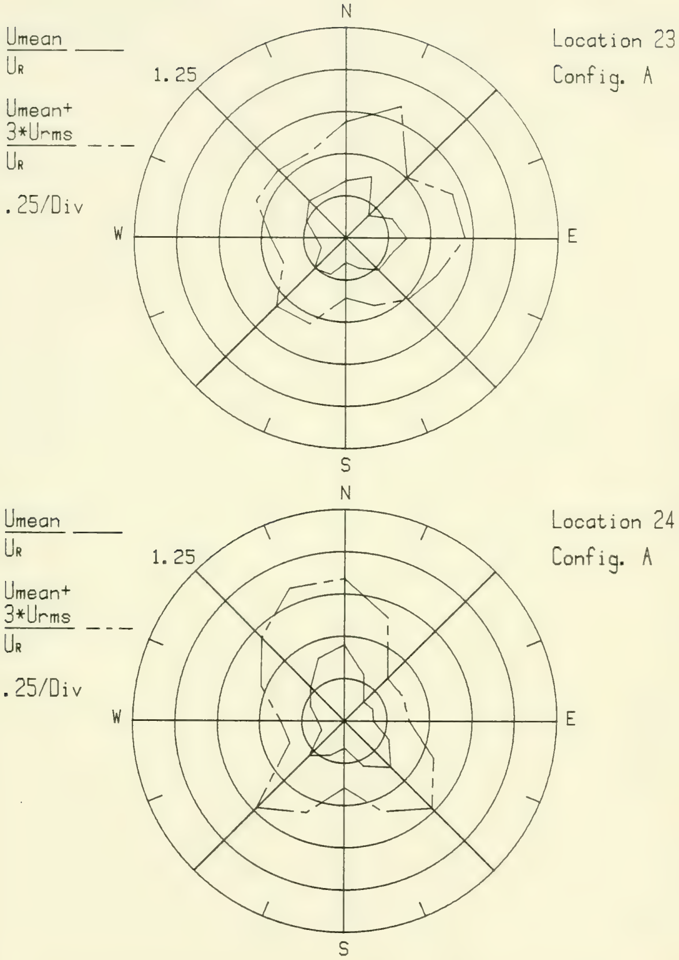
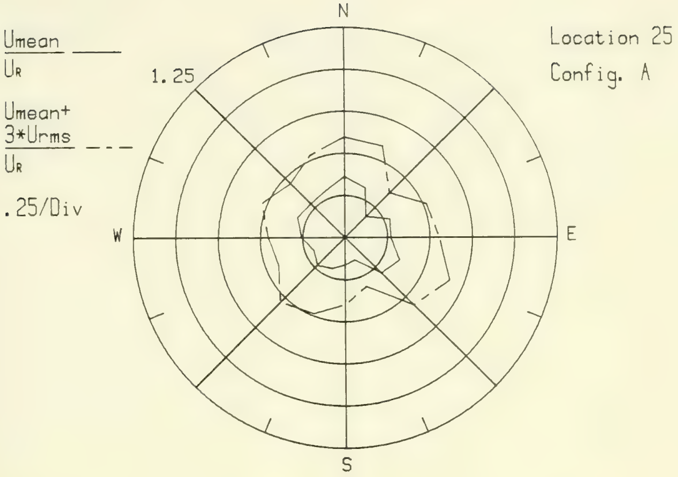


Figure 61 Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations



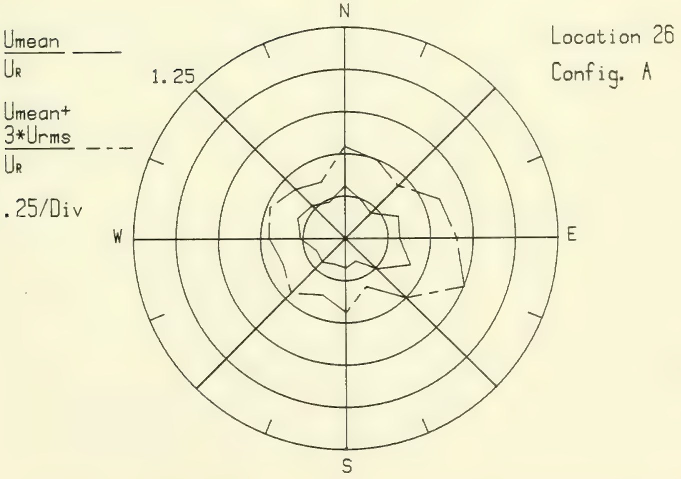
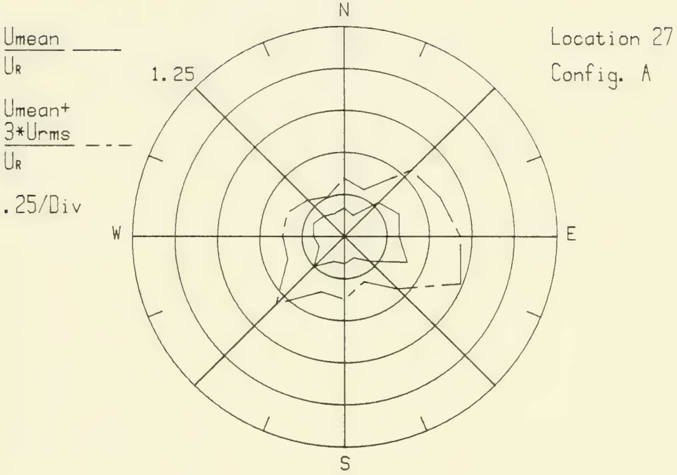


Figure 6m Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations



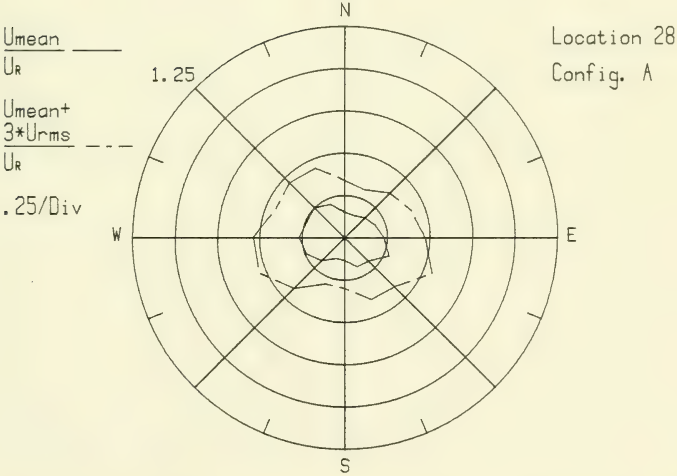


Figure 6n Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

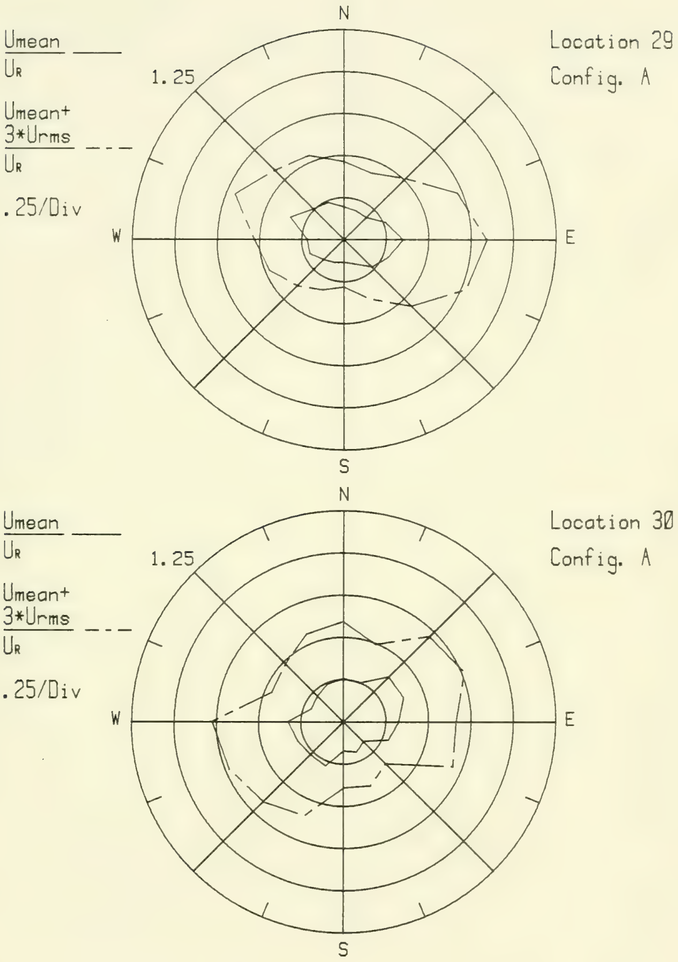


Figure 6o Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

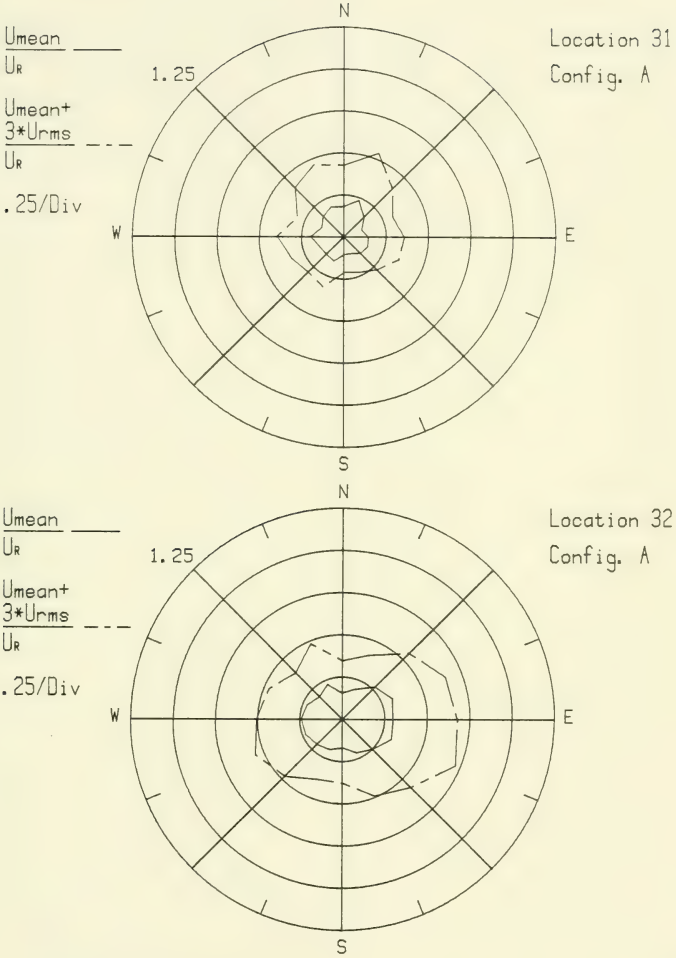


Figure 6p Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

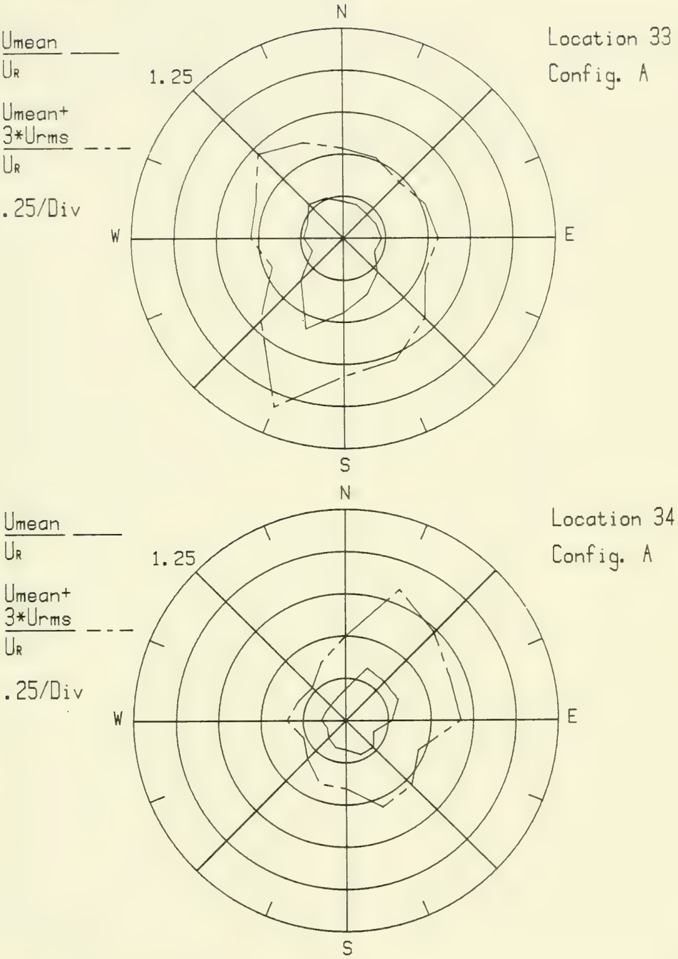


Figure 6q Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

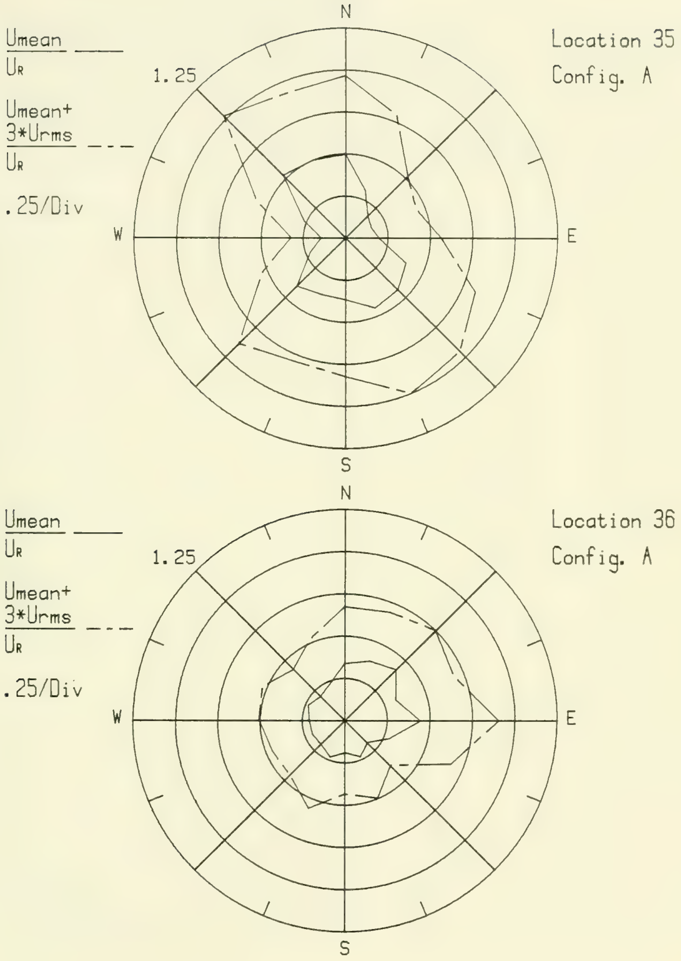


Figure 6r Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

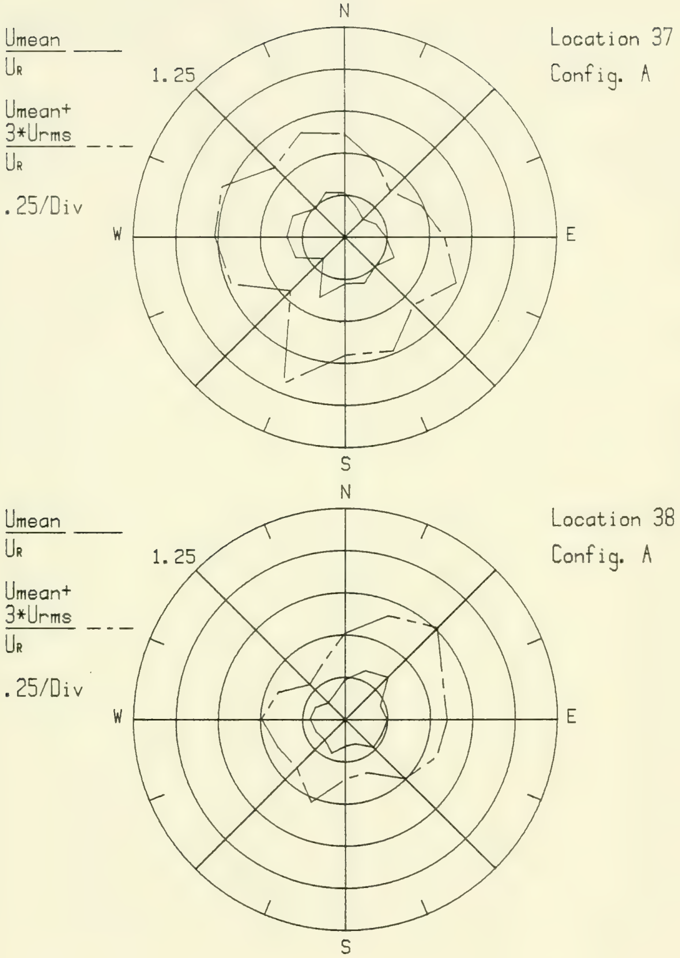
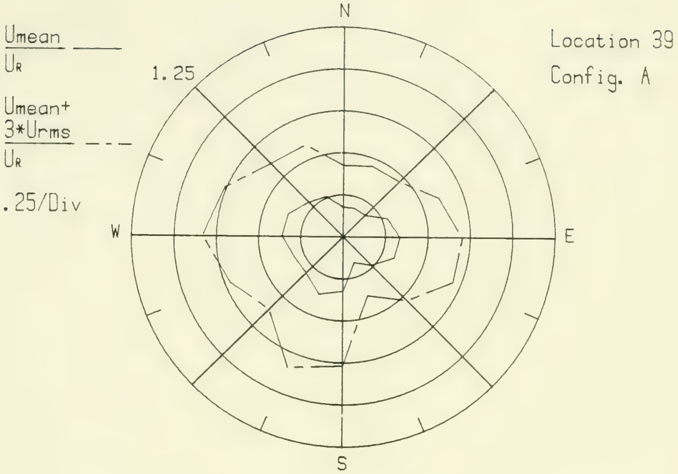


Figure 6s Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations



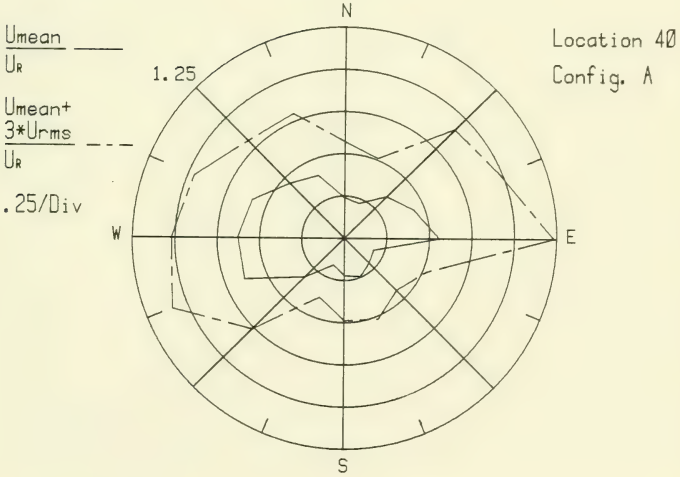


Figure 6t Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

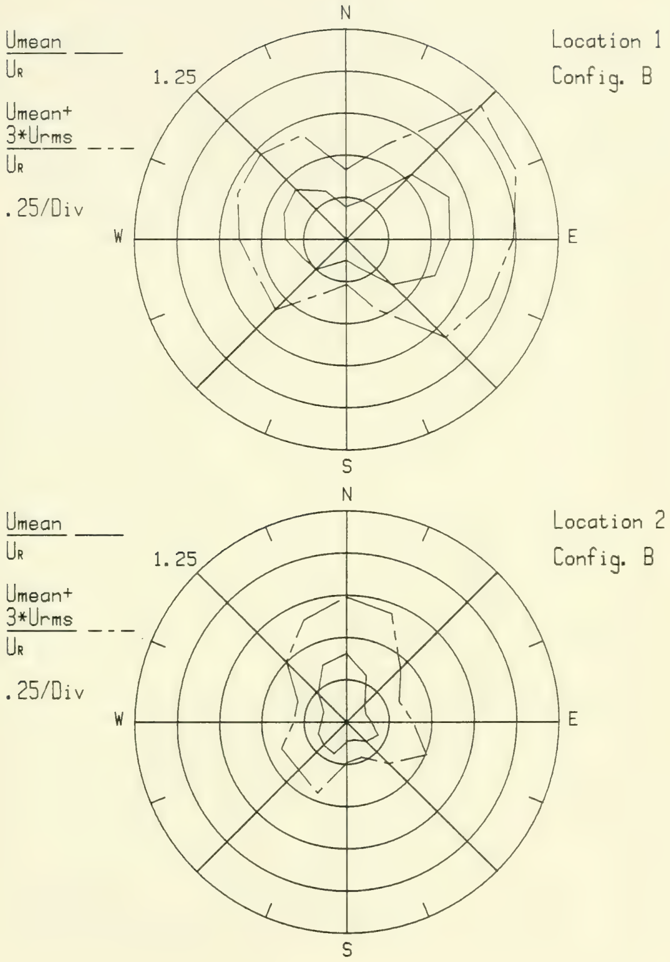


Figure 6u Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

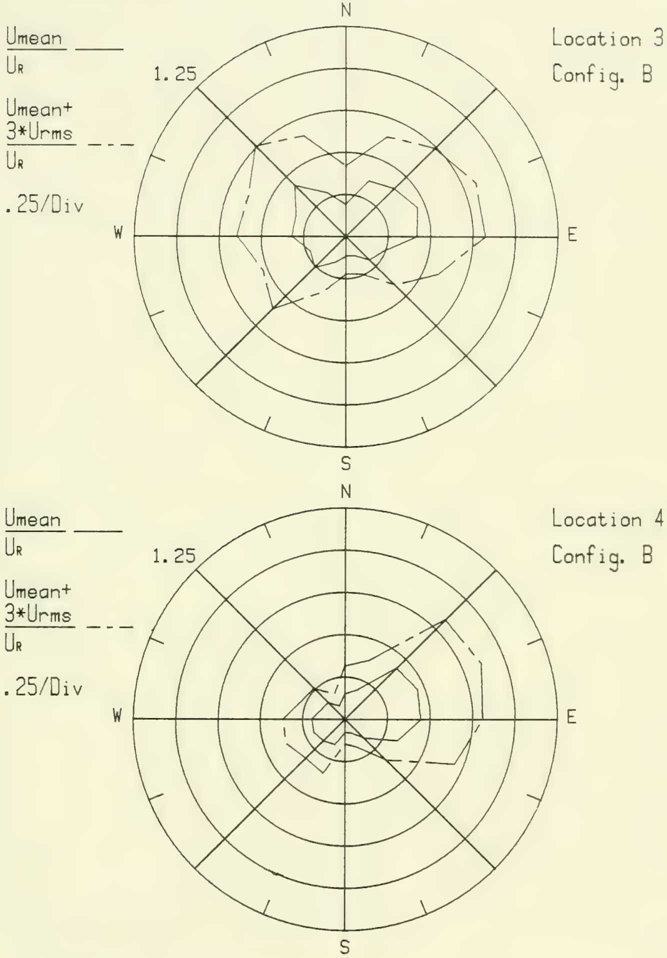


Figure 6v Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

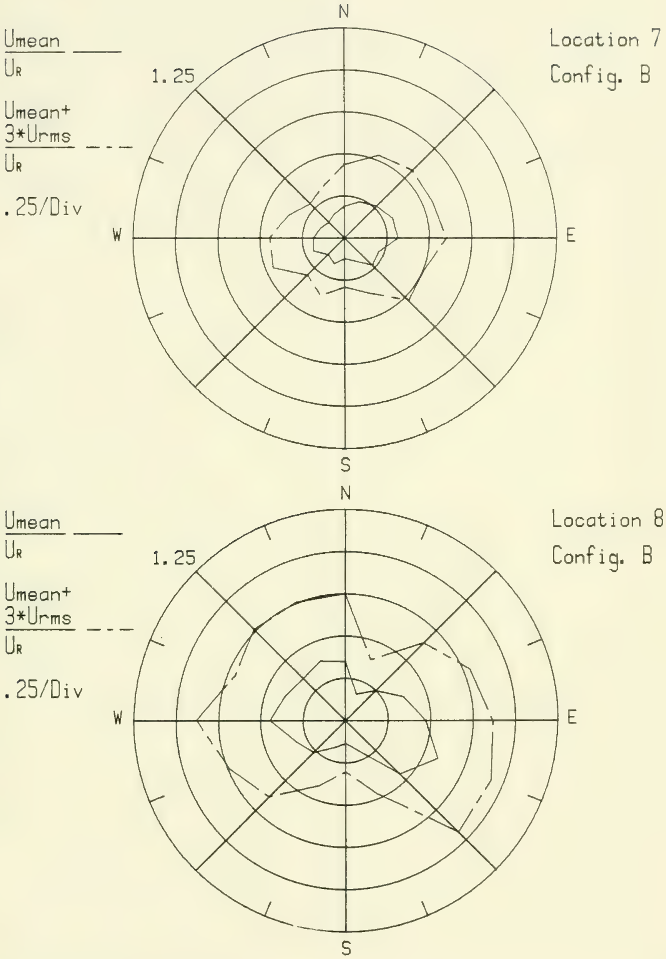


Figure 6x Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

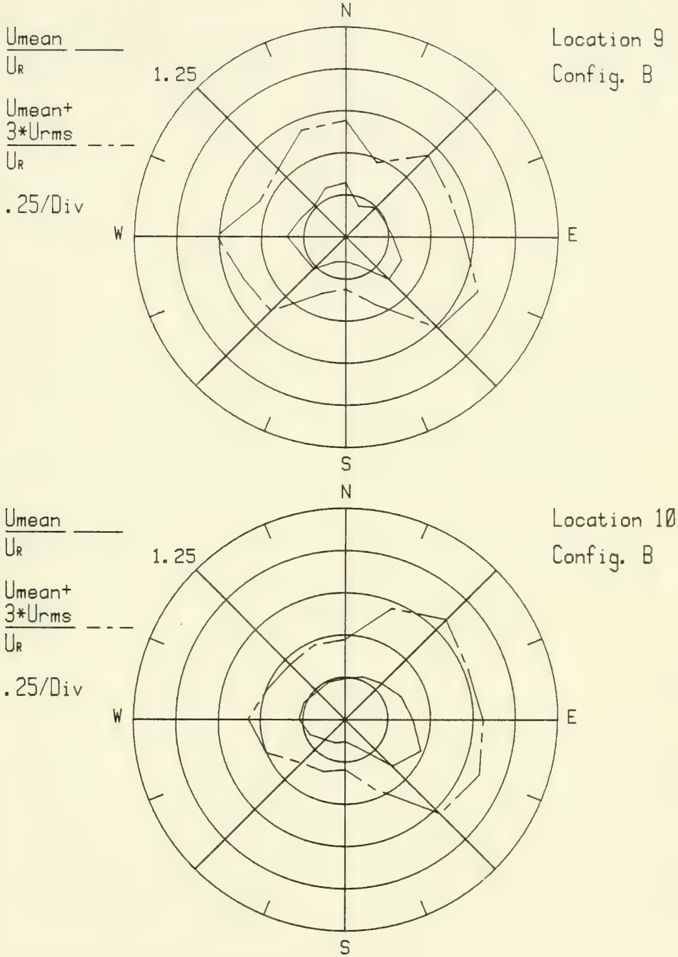


Figure 6y Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

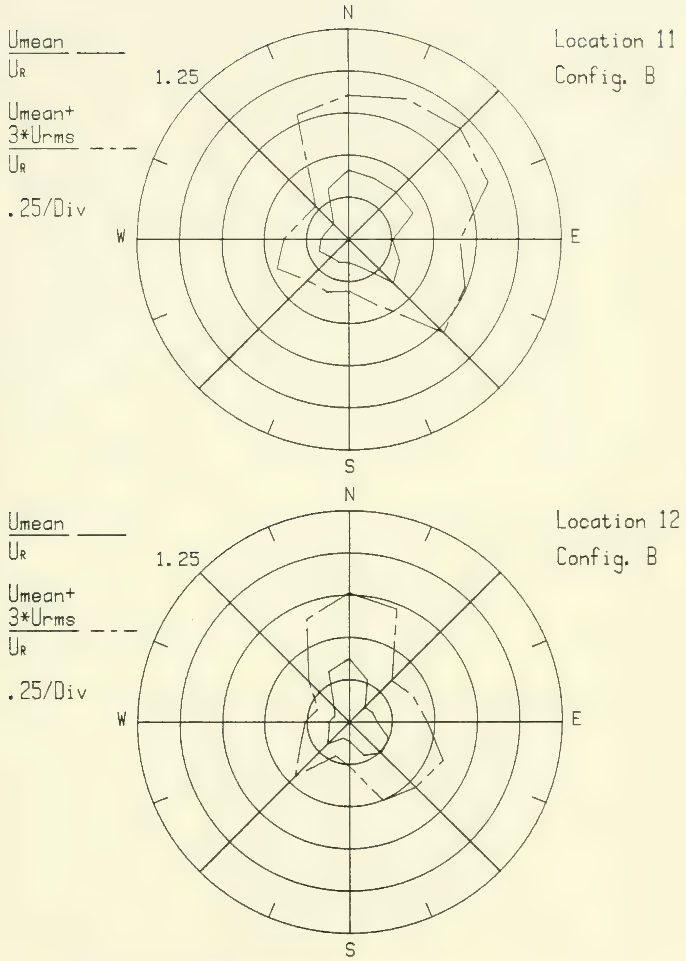


Figure 6z Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

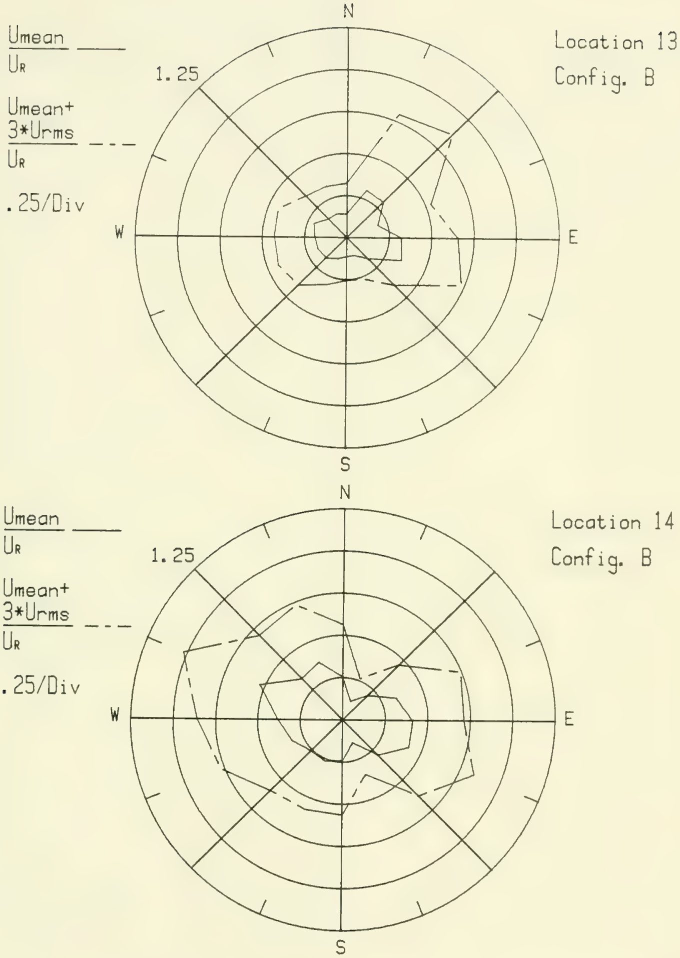


Figure 6aa Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

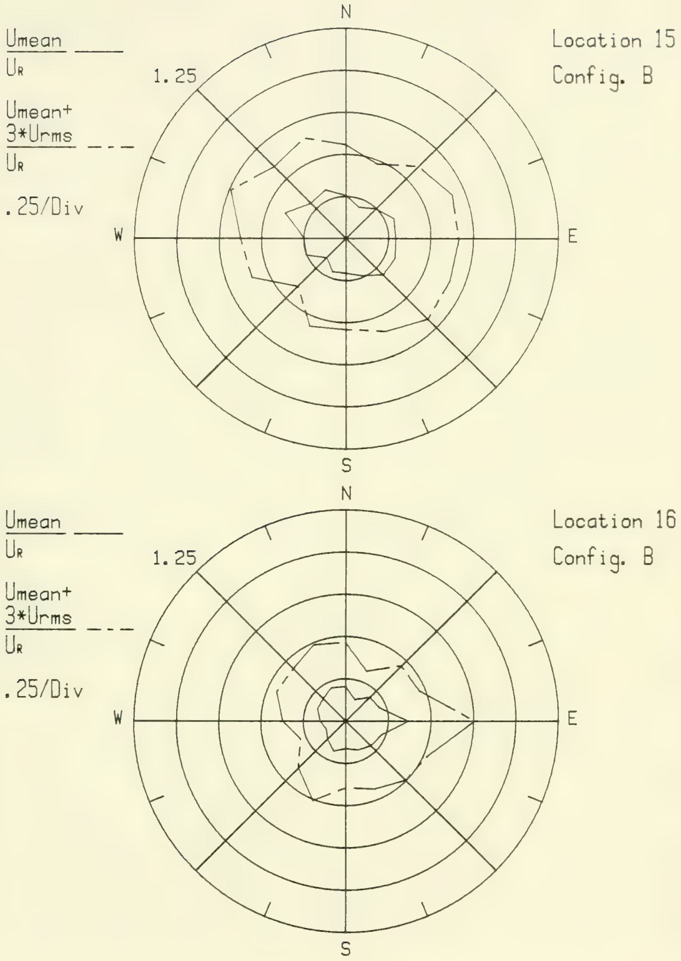


Figure 6bb Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

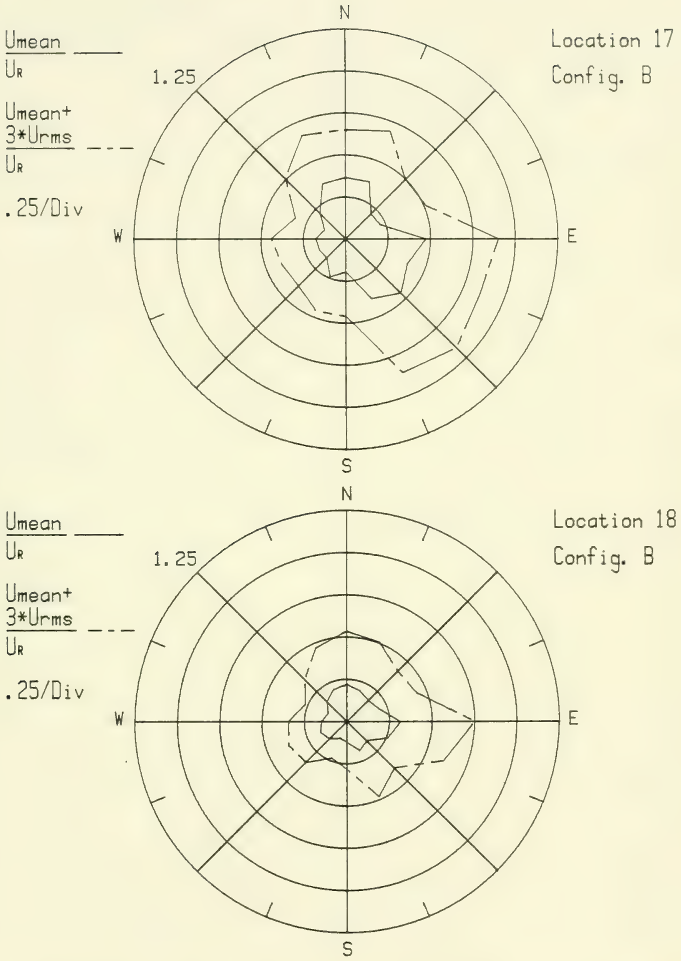


Figure 6cc Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

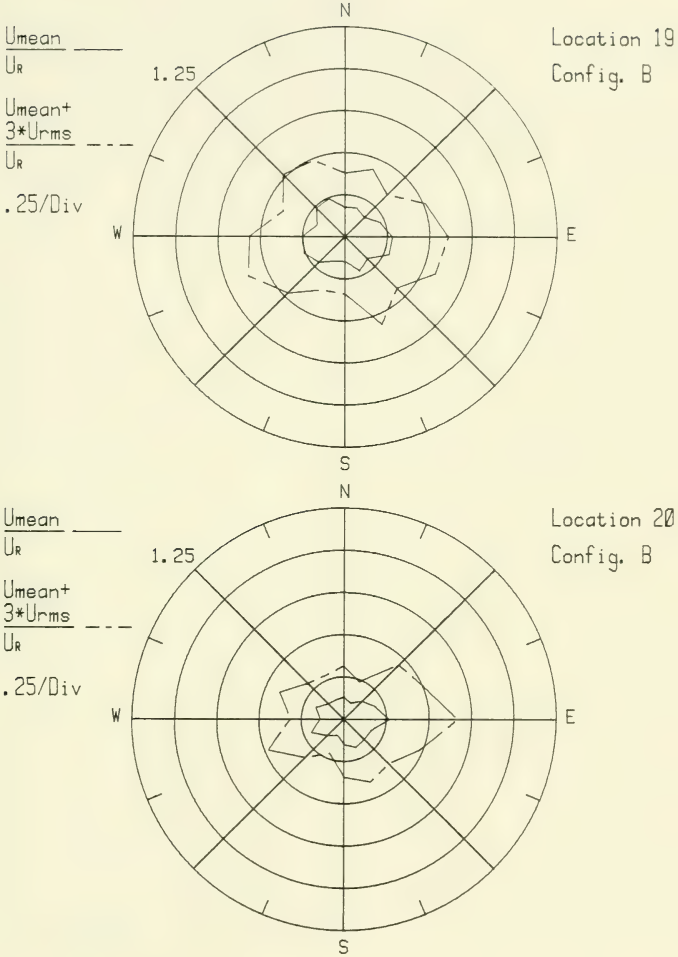


Figure 6dd Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

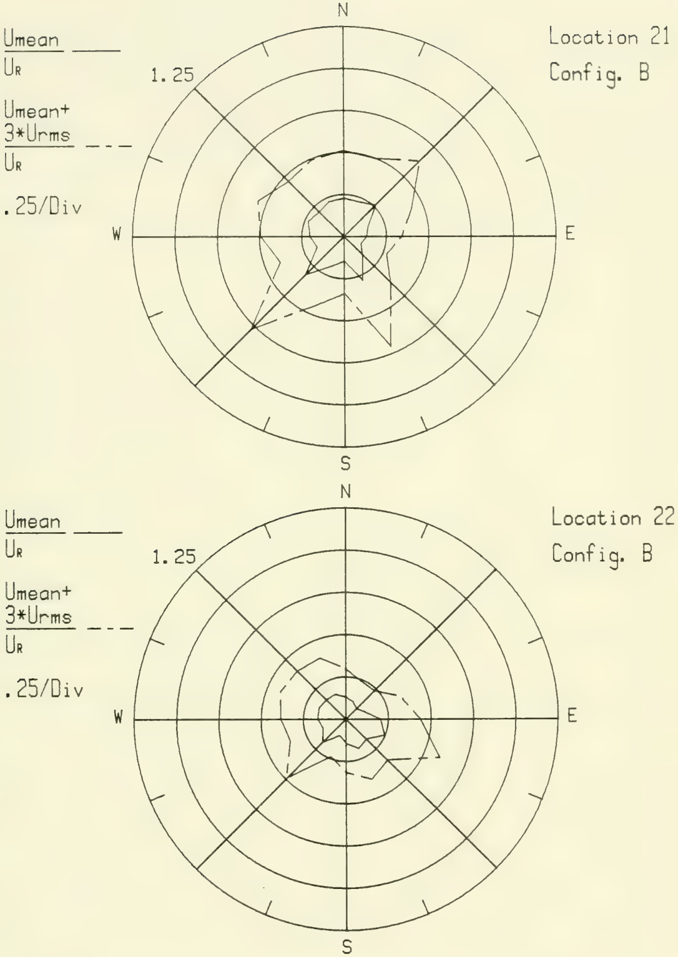


Figure 6ee Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

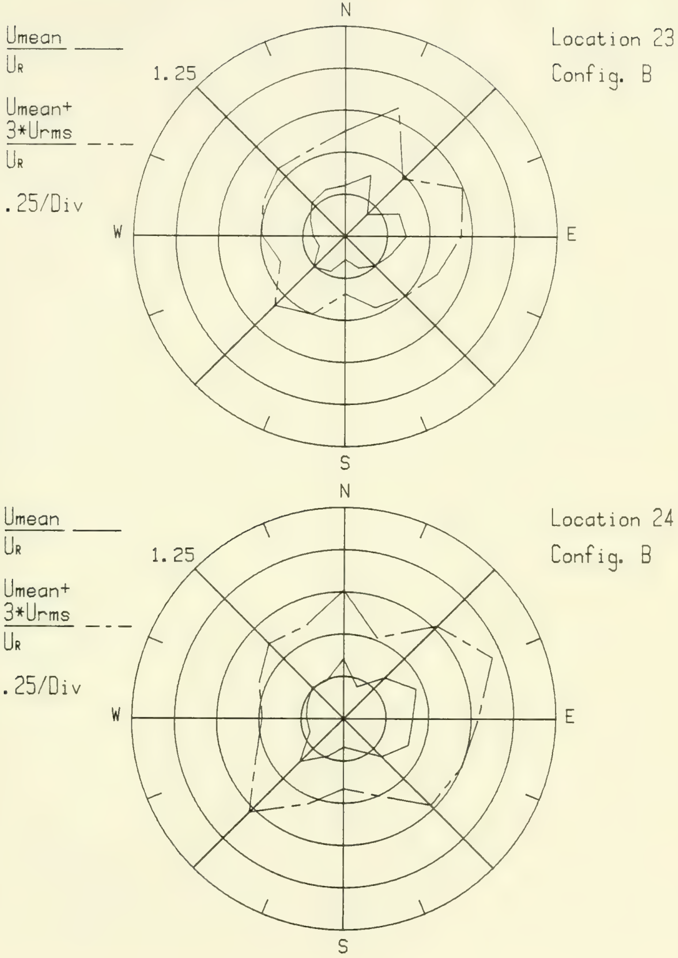


Figure 6ff Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

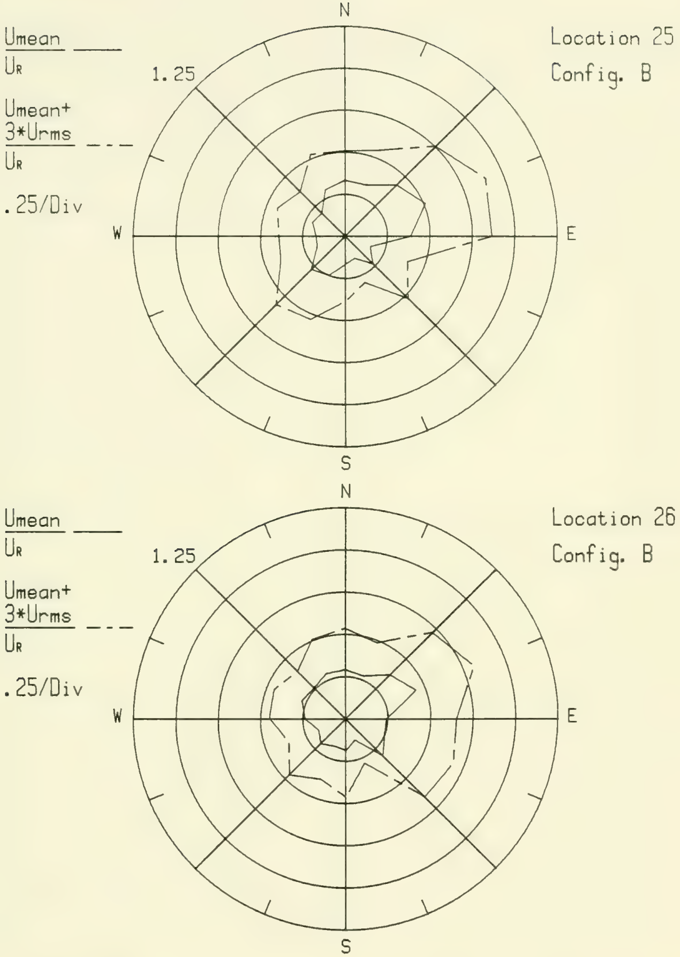


Figure 6gg Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

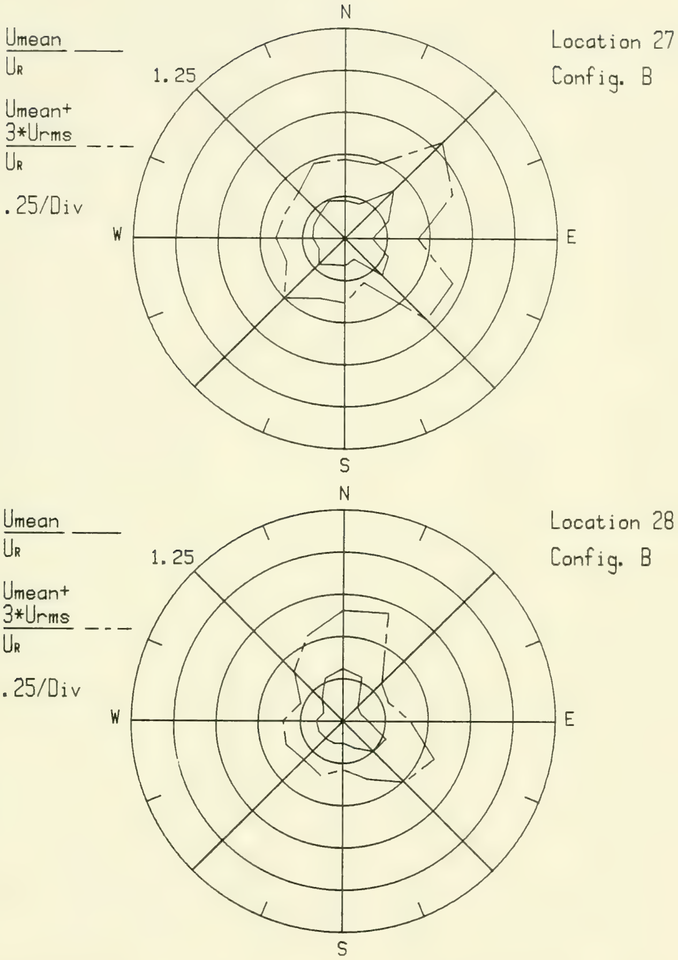


Figure 6hh Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

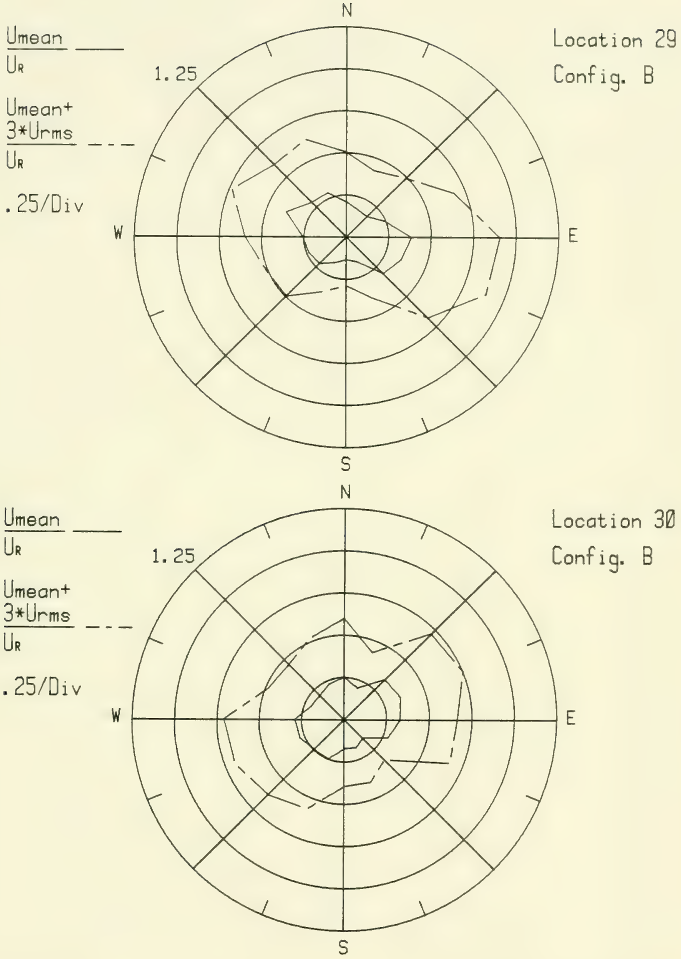


Figure 6ii Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

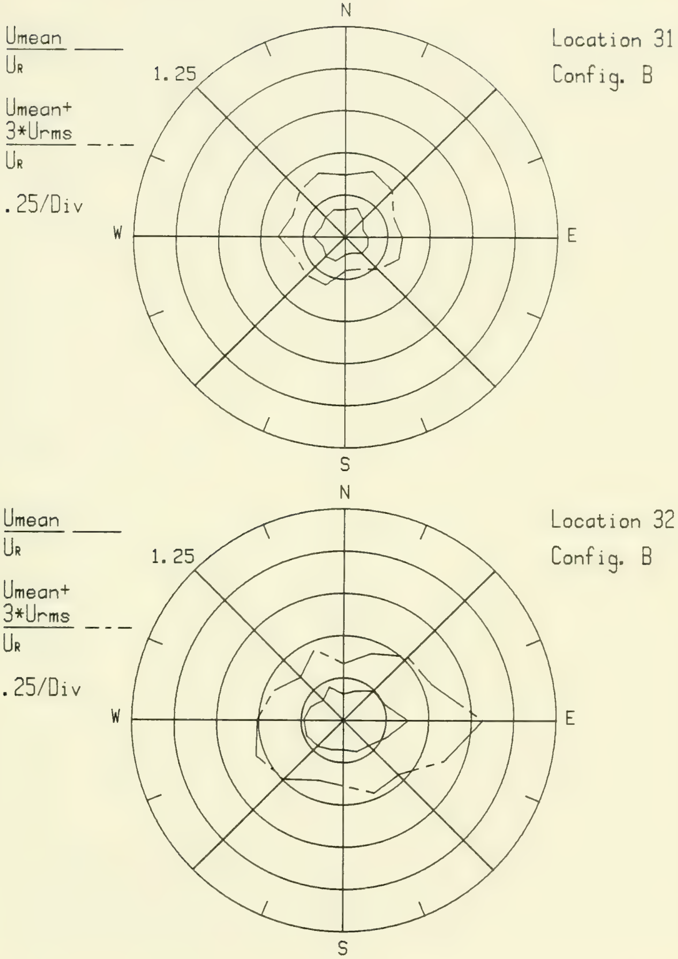
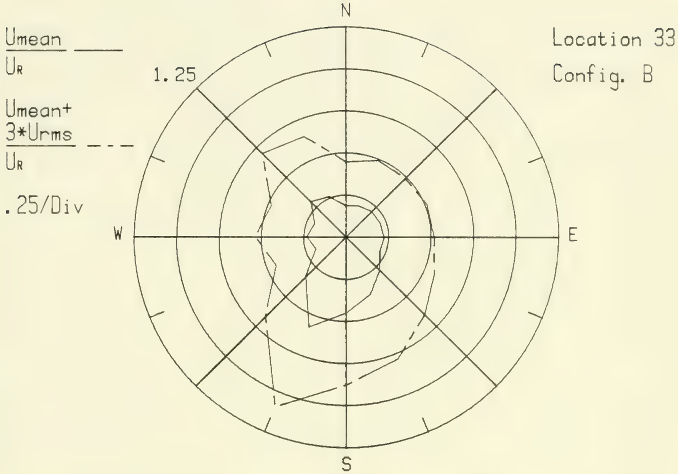


Figure 6jj Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations



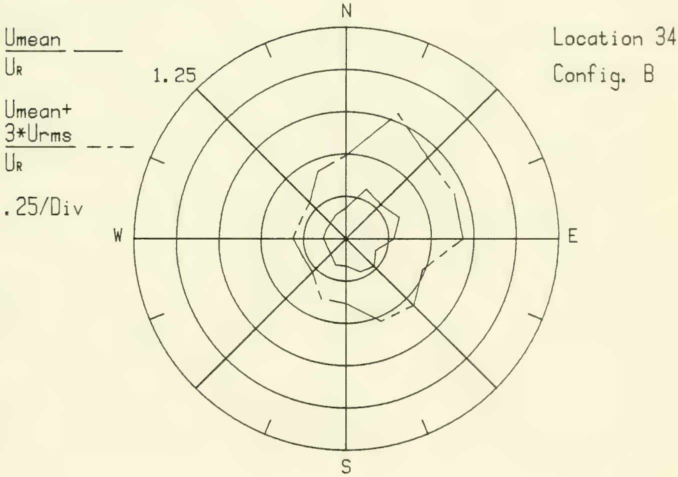


Figure 6kk Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

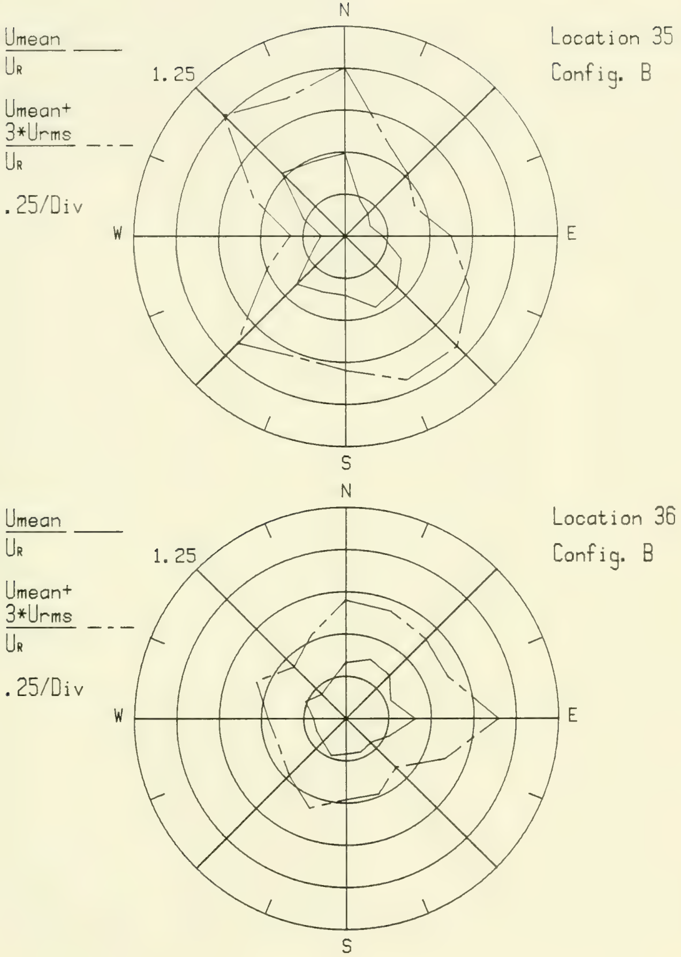


Figure 611 Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

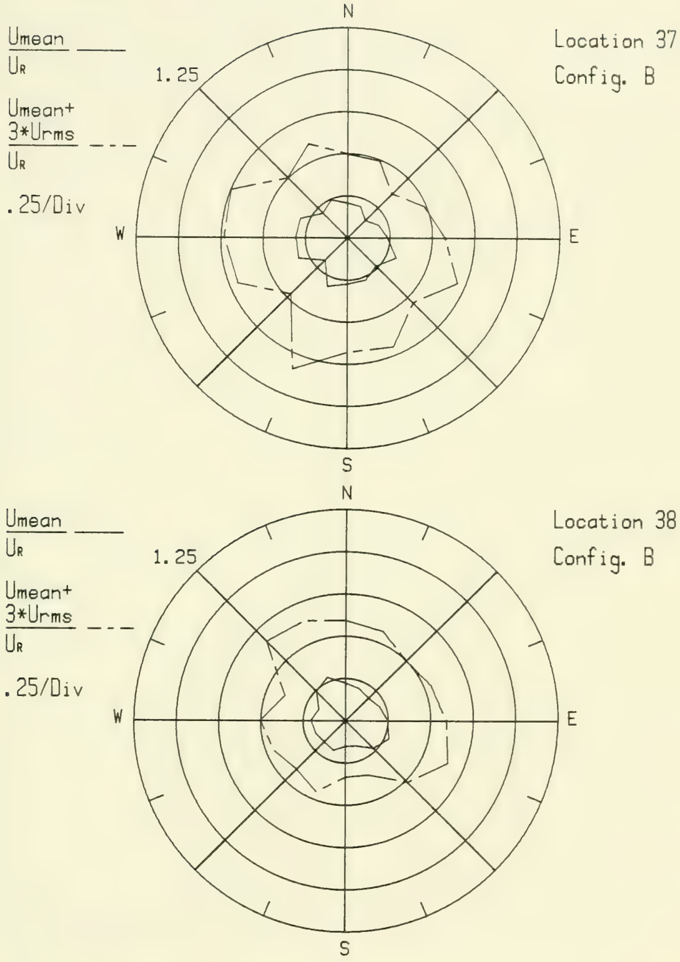


Figure 6mm Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

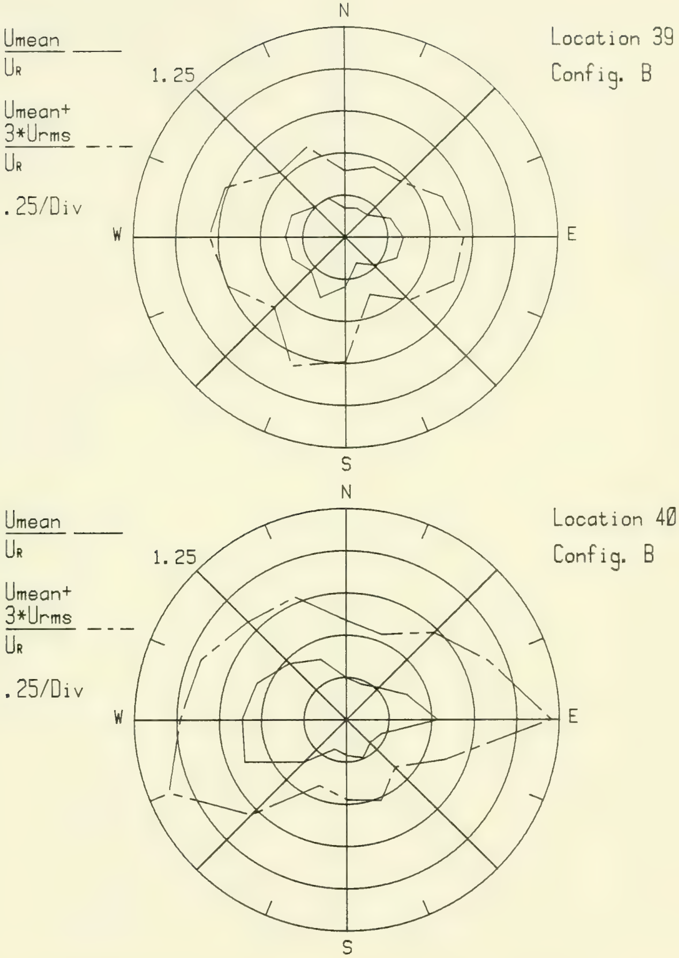


Figure 6nn Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

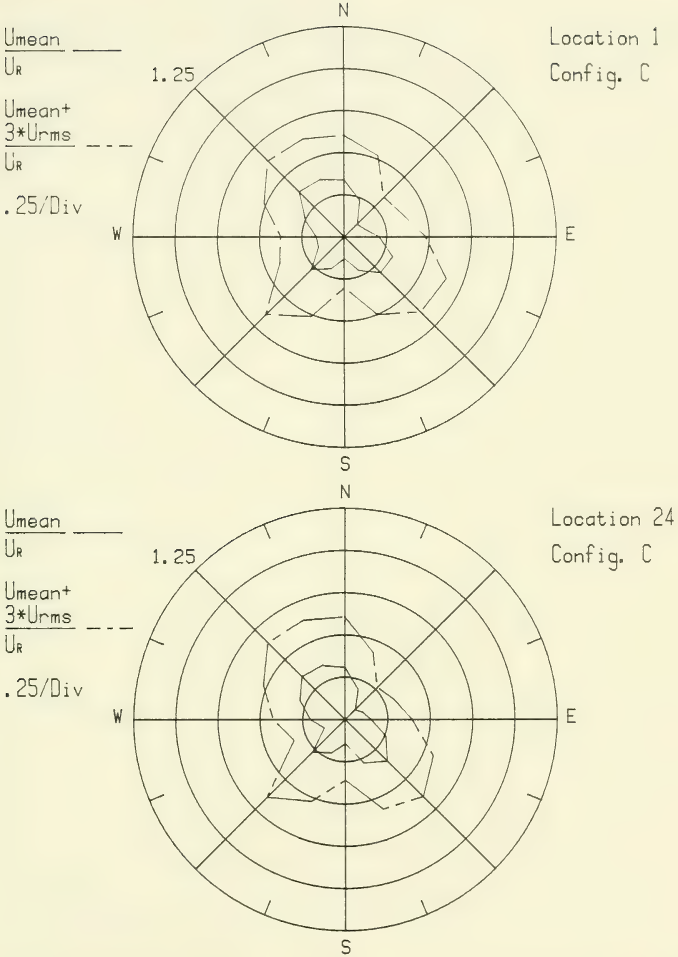


Figure 600 Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

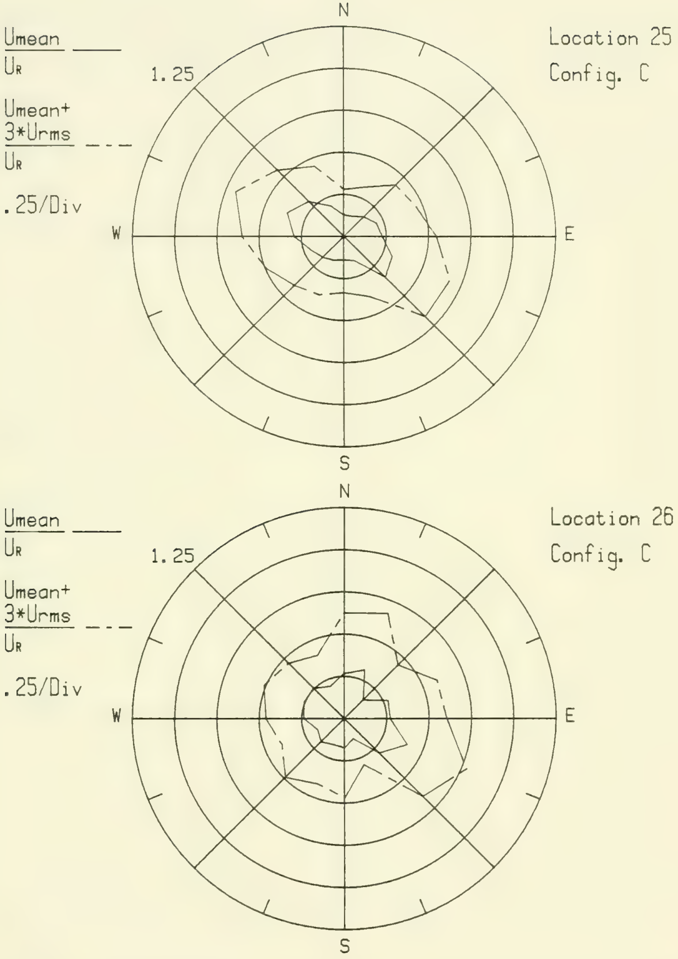
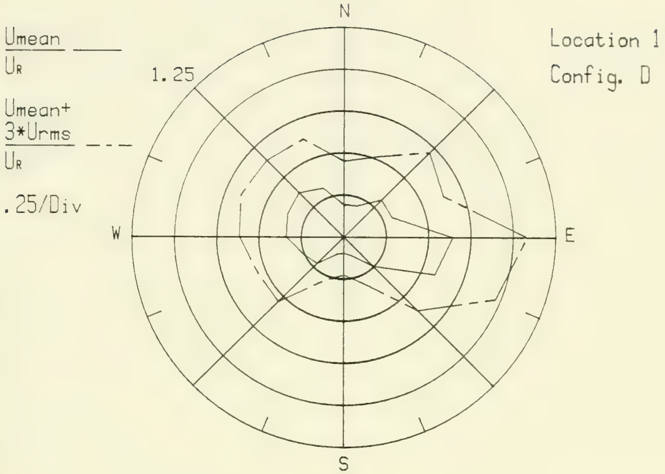


Figure 6pp Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations



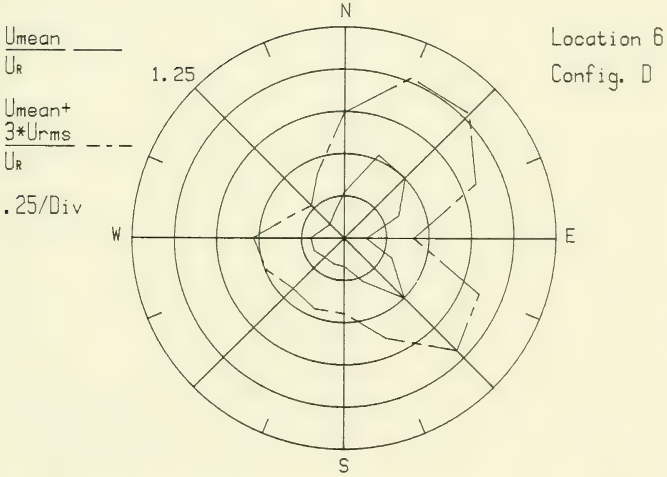


Figure 6qq Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

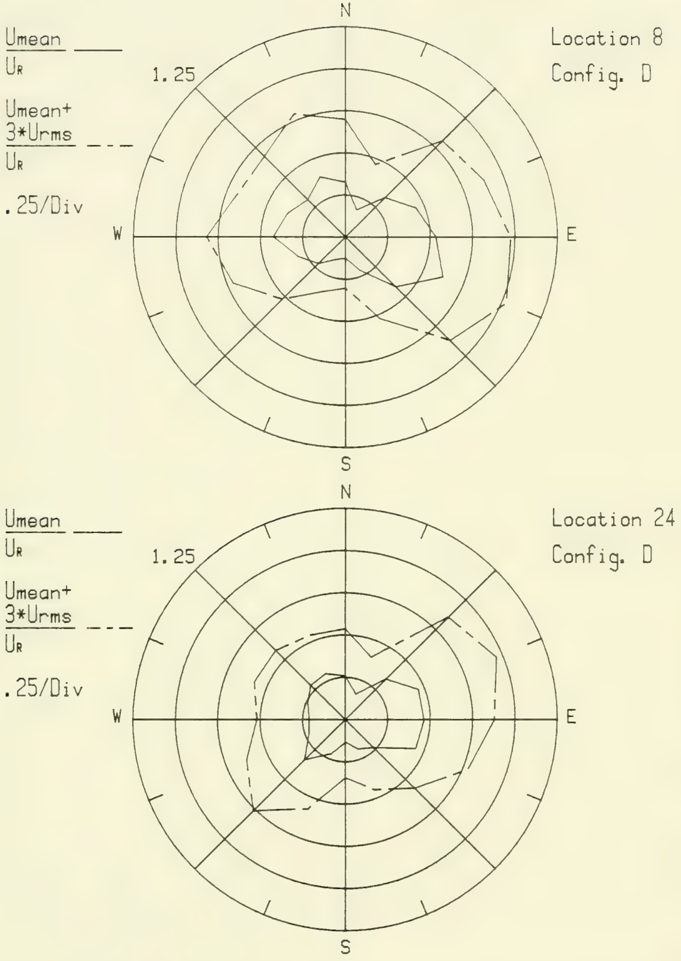


Figure 6rr Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

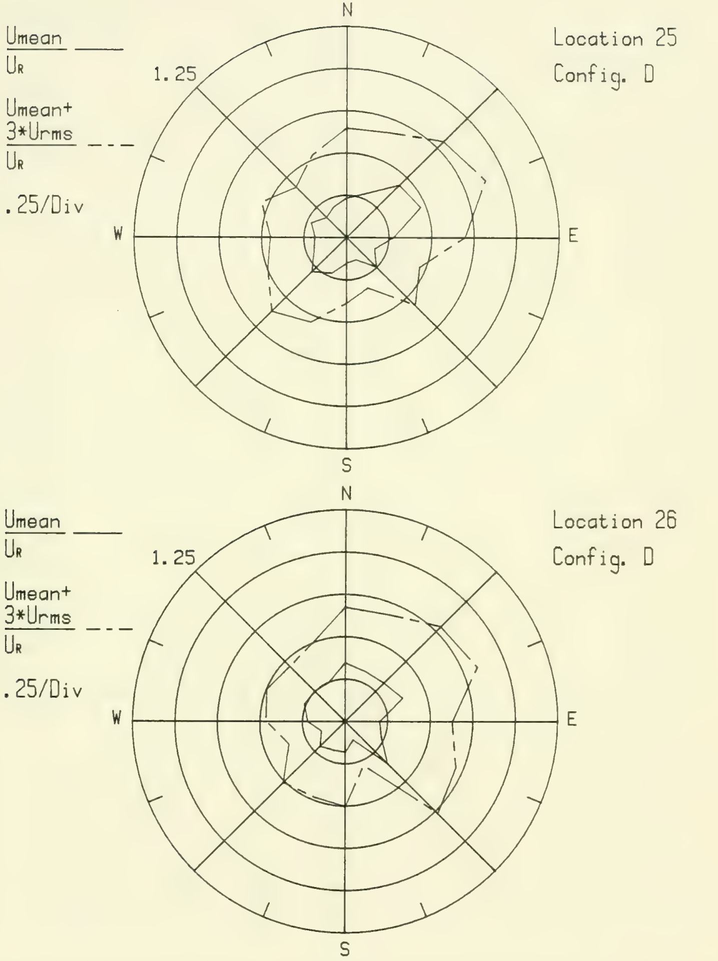


Figure 6ss Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

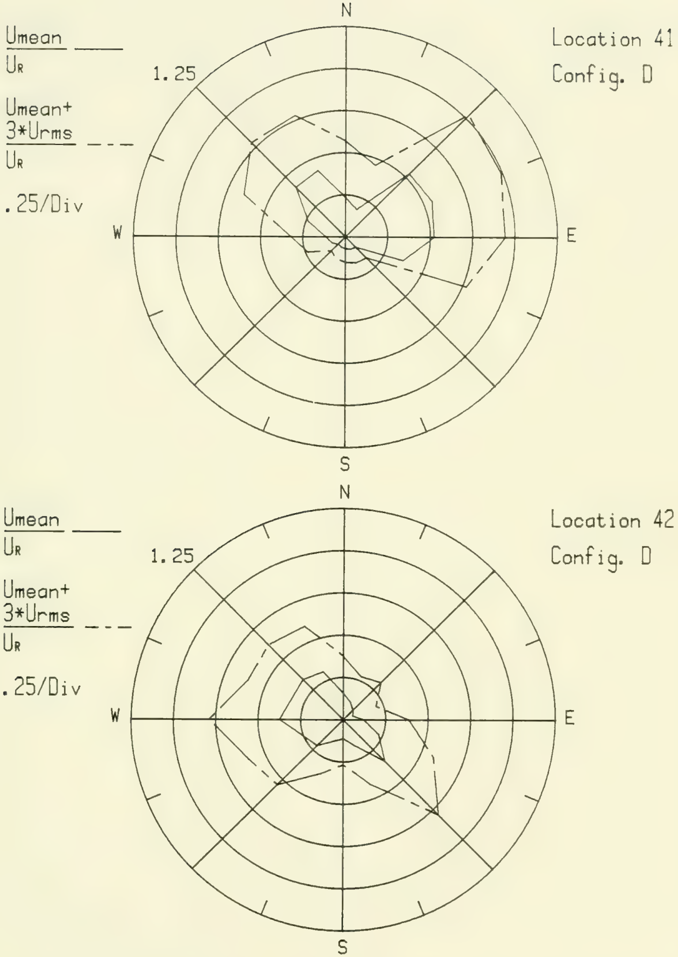


Figure 6tt Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

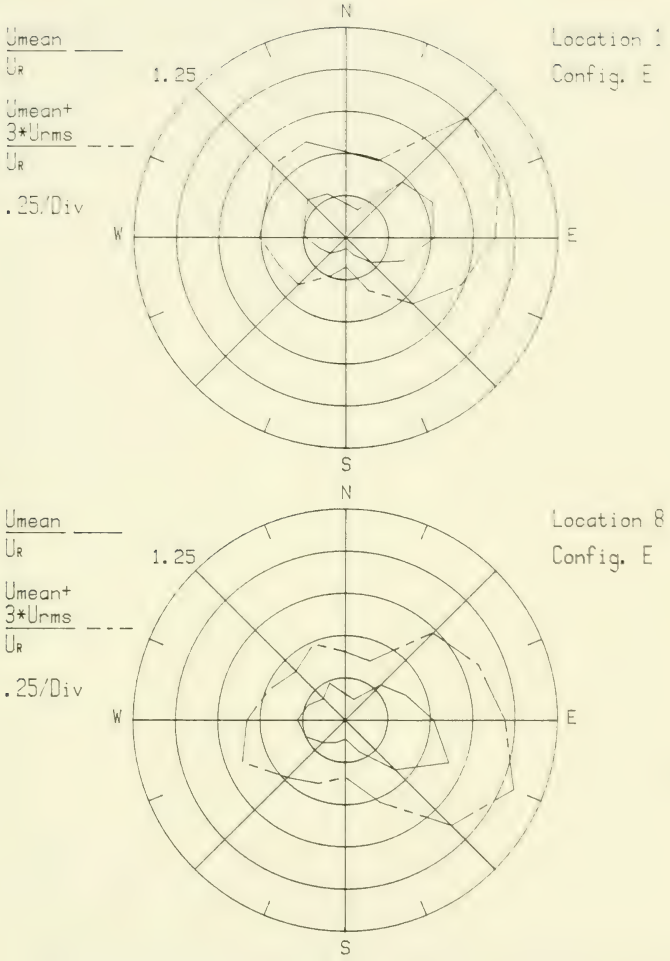


Figure 6uu Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

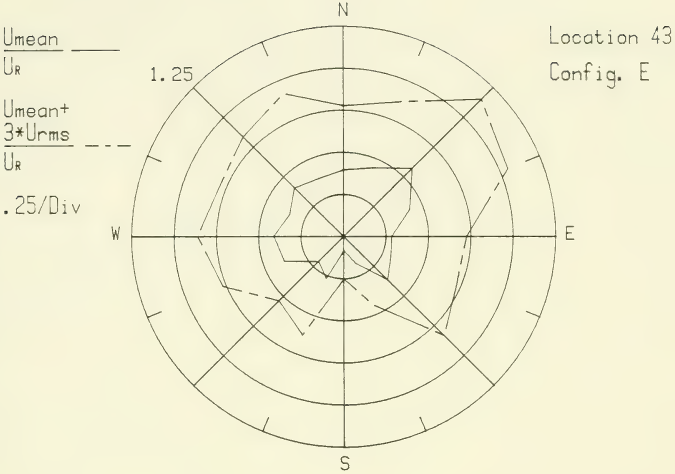


Figure 6vv Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

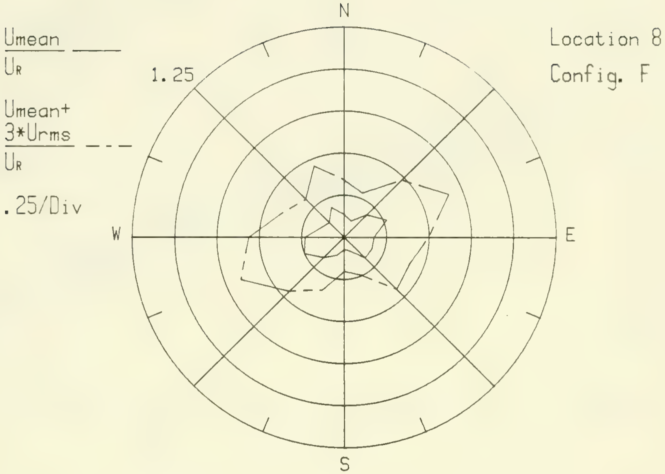


Figure 6ww Non-Dimensional Mean Velocities and Peak Gusts at Pedestrian Locations

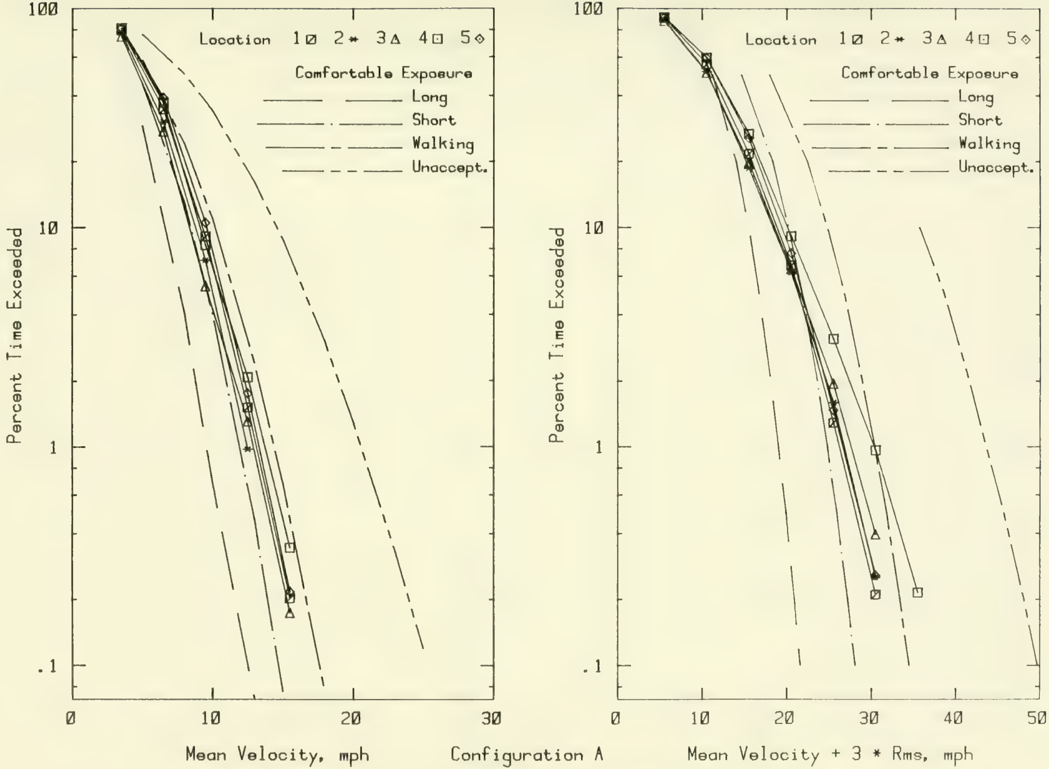


Figure 7a Wind Velocity Probabilities for Pedestrian Locations

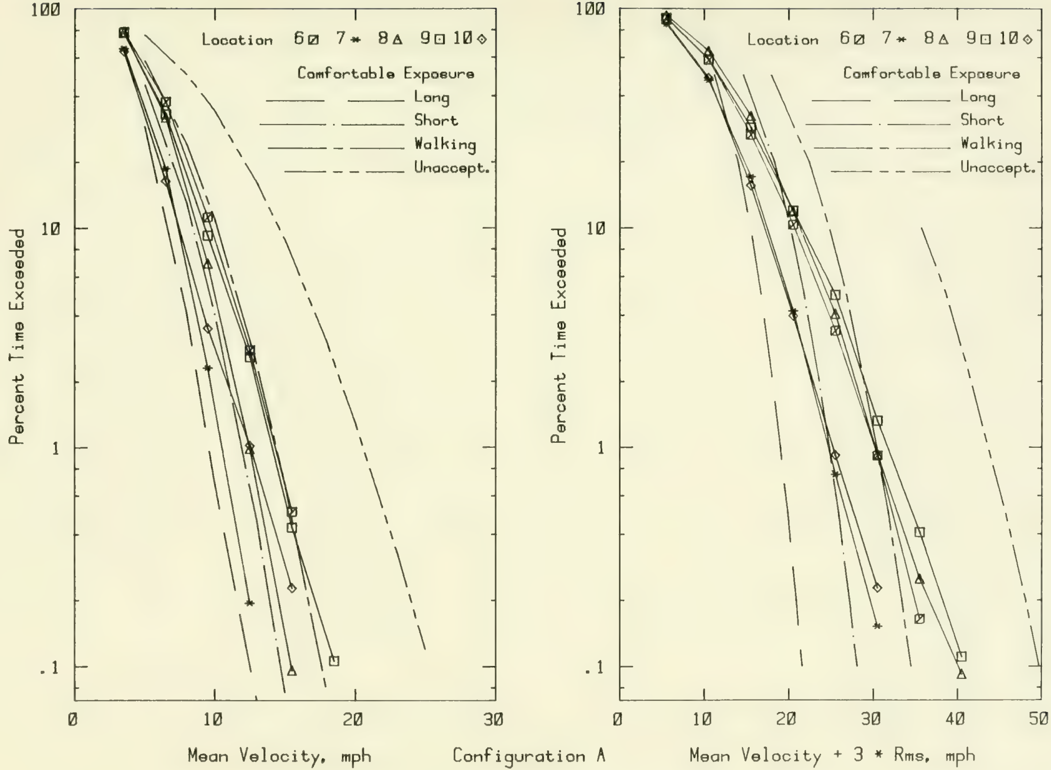


Figure 7b Wind Velocity Probabilities for Pedestrian Locations

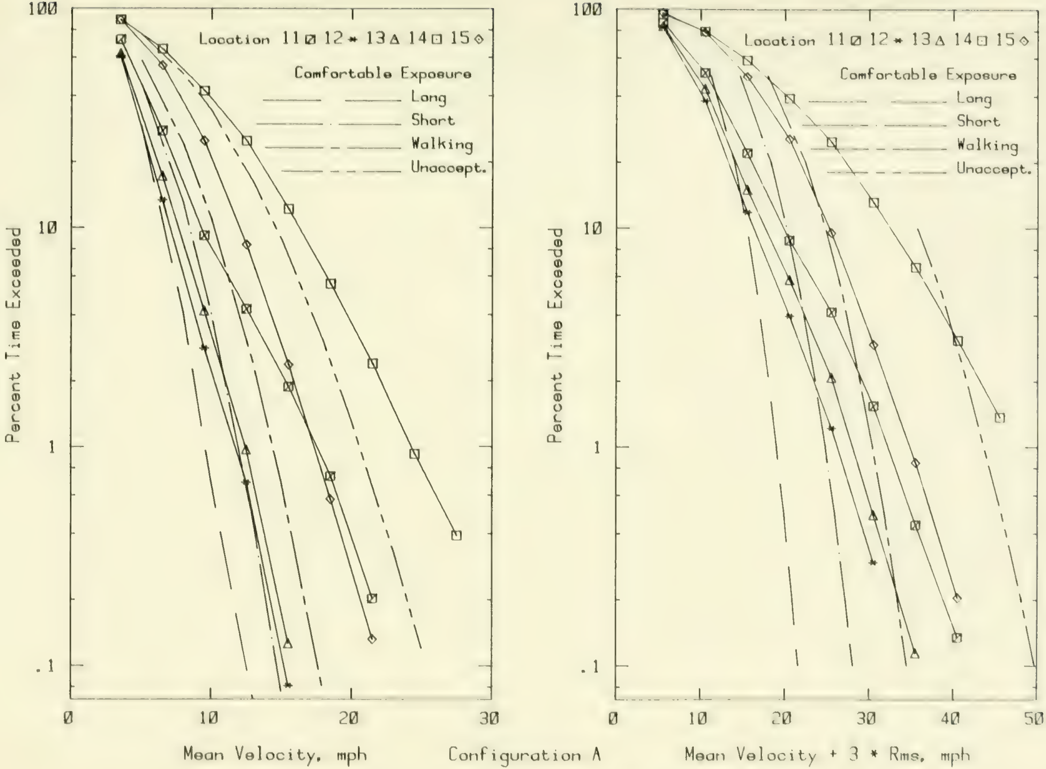


Figure 7c Wind Velocity Probabilities for Pedestrian Locations

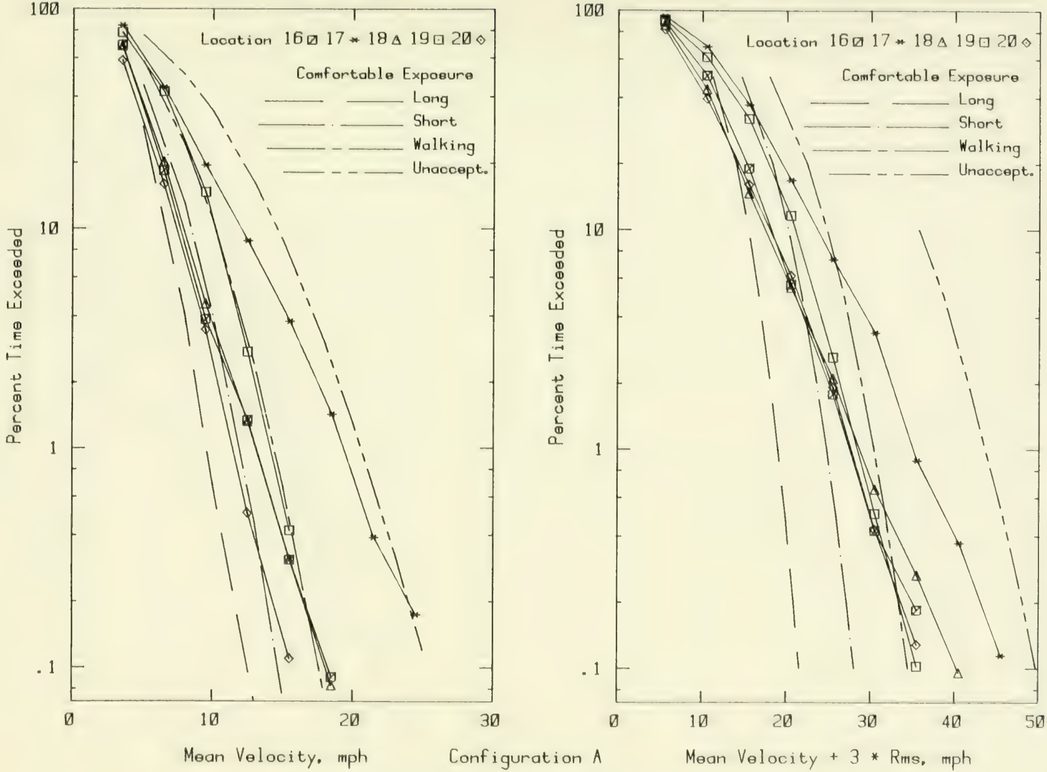


Figure 7d Wind Velocity Probabilities for Pedestrian Locations

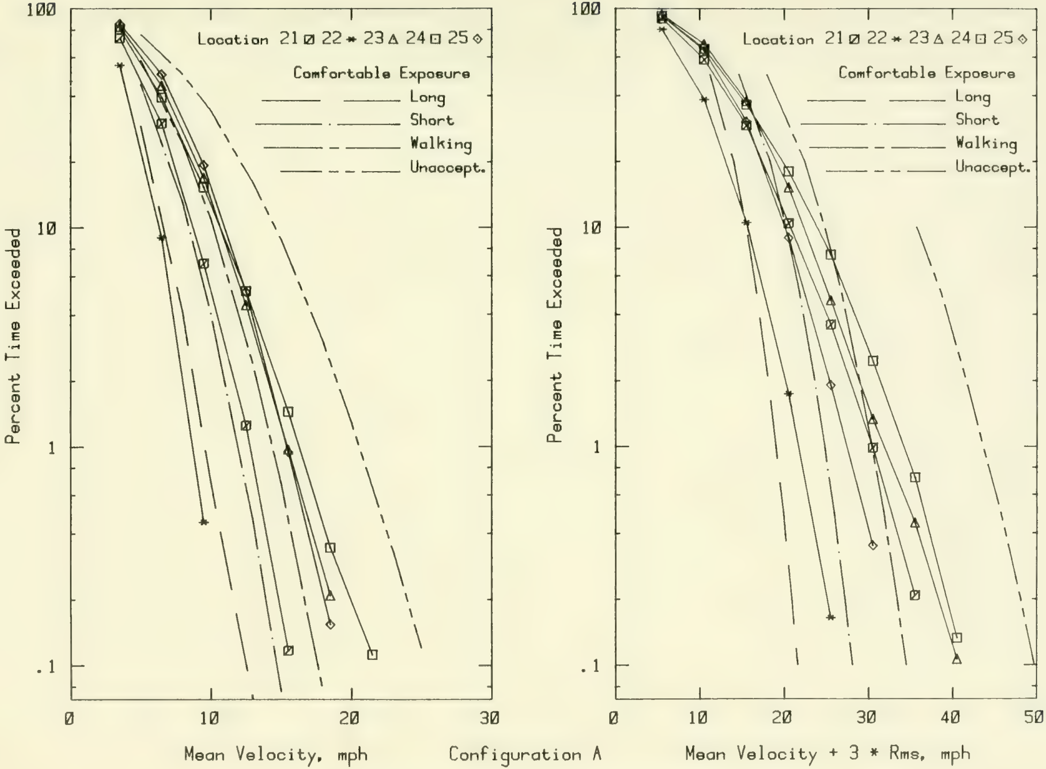


Figure 7e Wind Velocity Probabilities for Pedestrian Locations

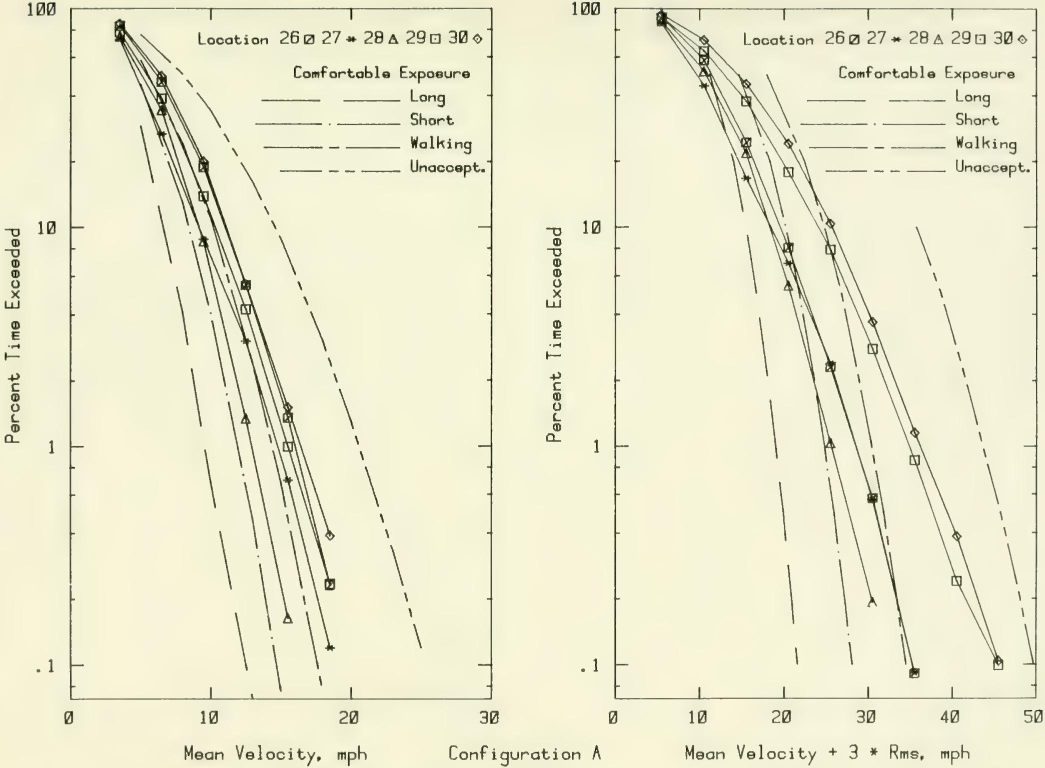


Figure 7f Wind Velocity Probabilities for Pedestrian Locations

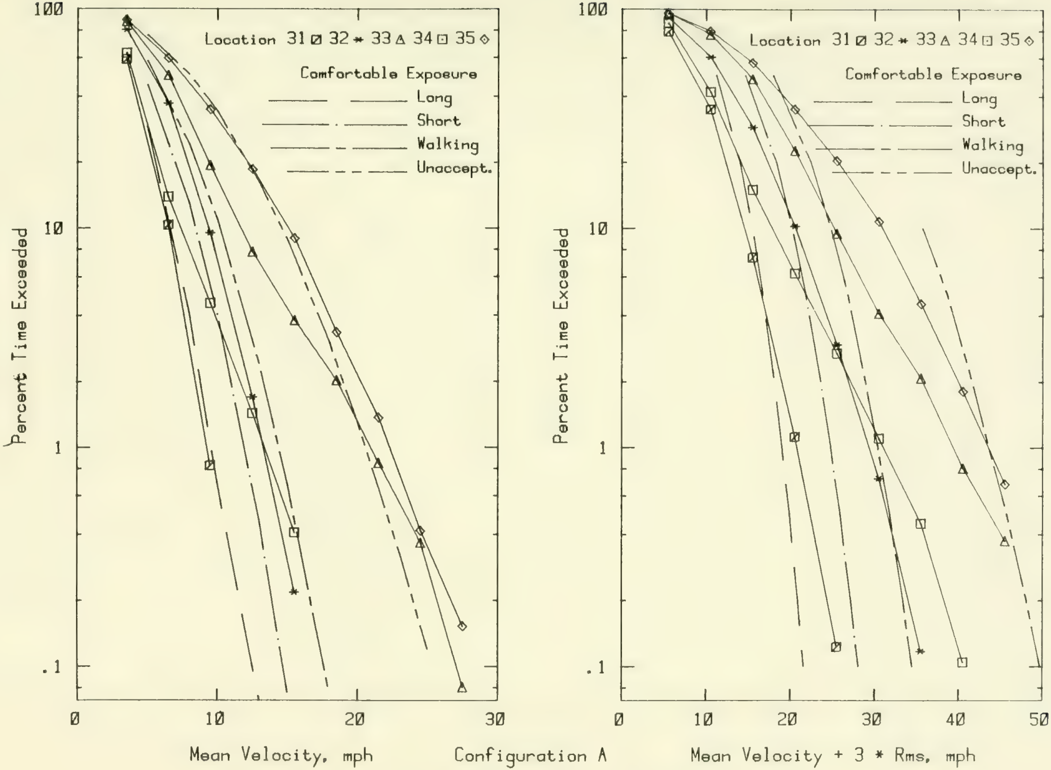


Figure 7g Wind Velocity Probabilities for Pedestrian Locations

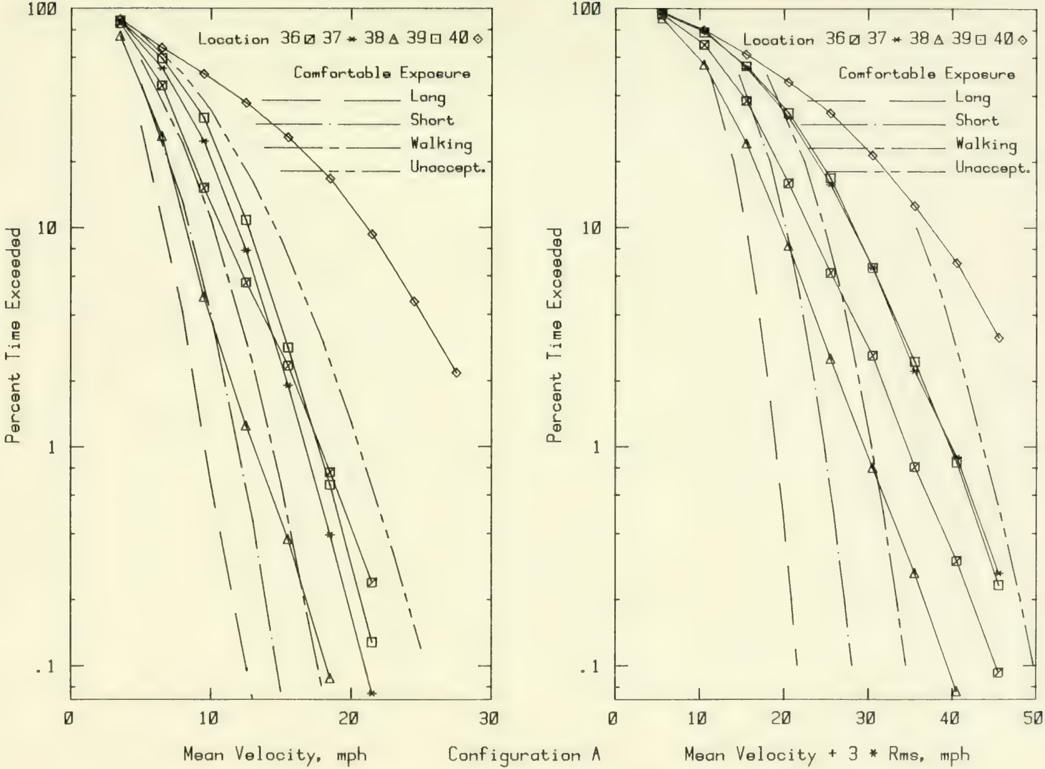


Figure 7h Wind Velocity Probabilities for Pedestrian Locations

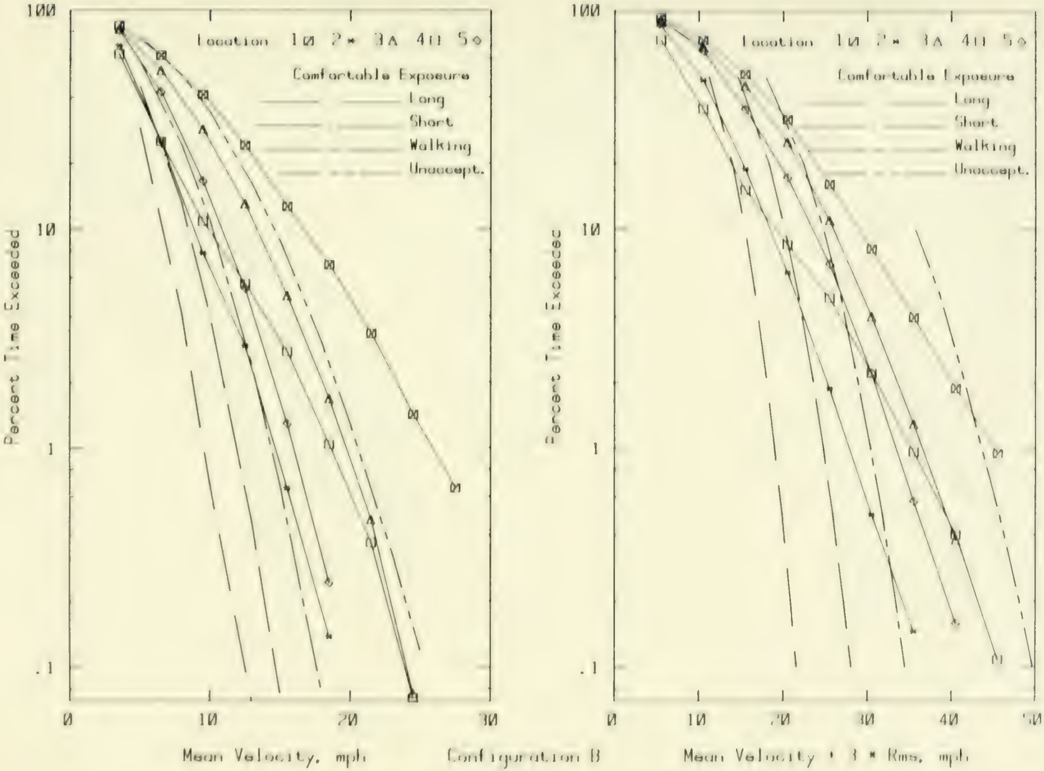


Figure 71 Wind Velocity Probabilities for Pedestrian Locations

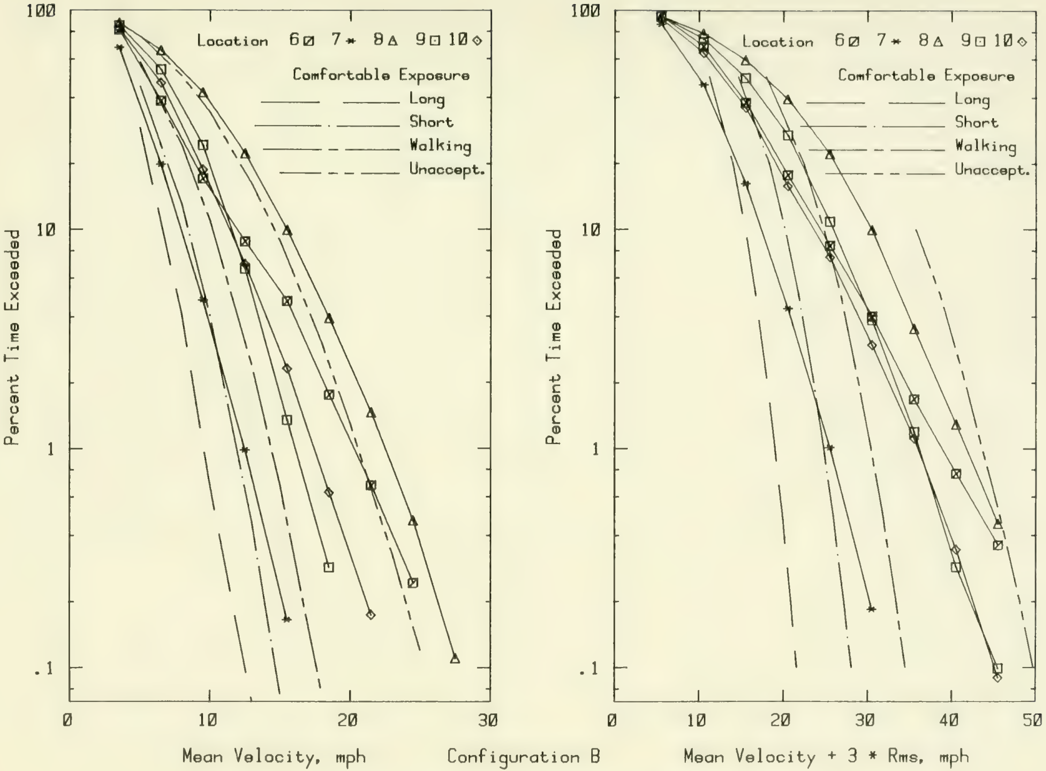


Figure 7j Wind Velocity Probabilities for Pedestrian Locations

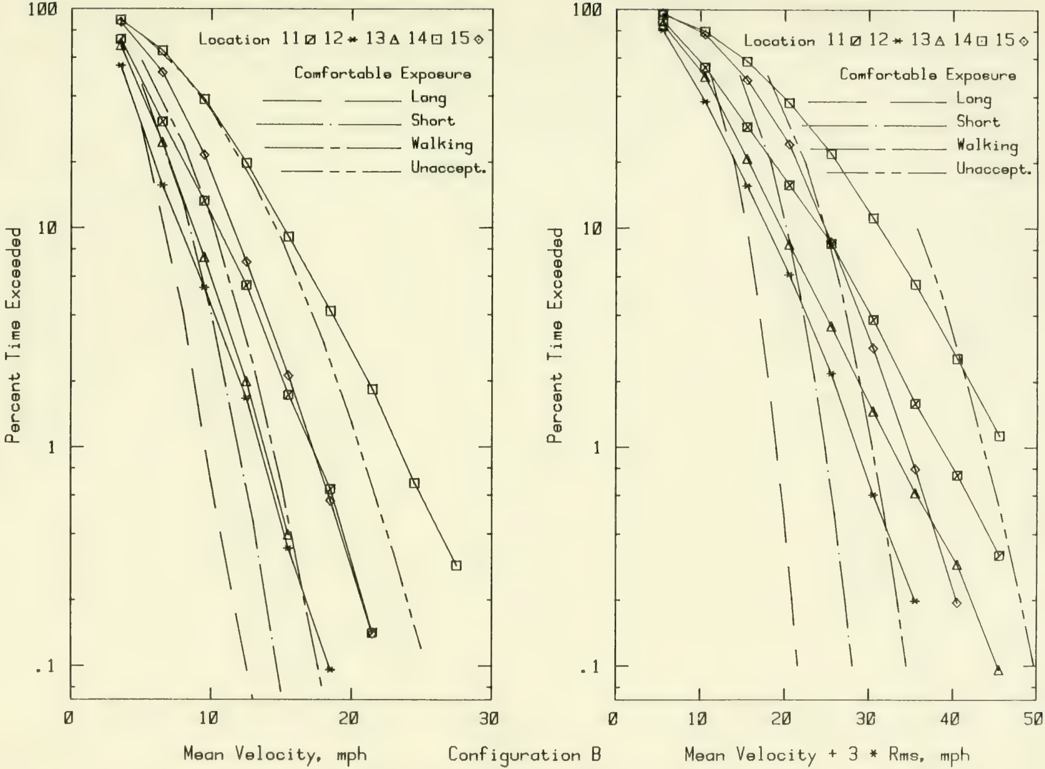


Figure 7k Wind Velocity Probabilities for Pedestrian Locations

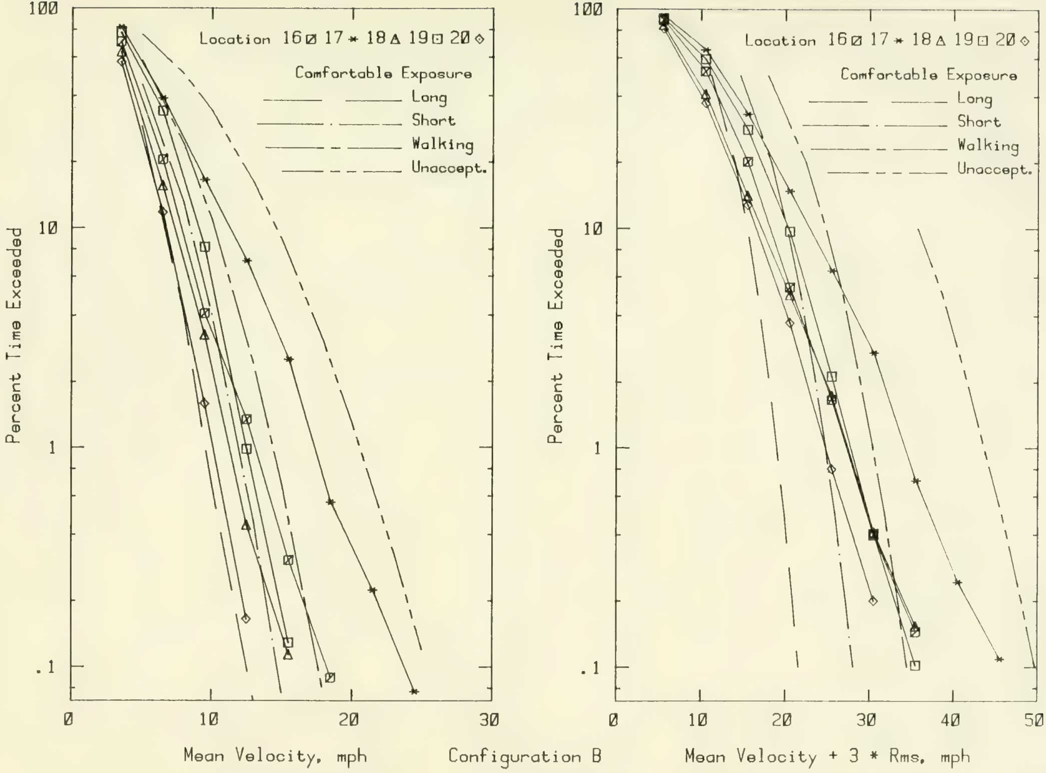


Figure 71 Wind Velocity Probabilities for Pedestrian Locations

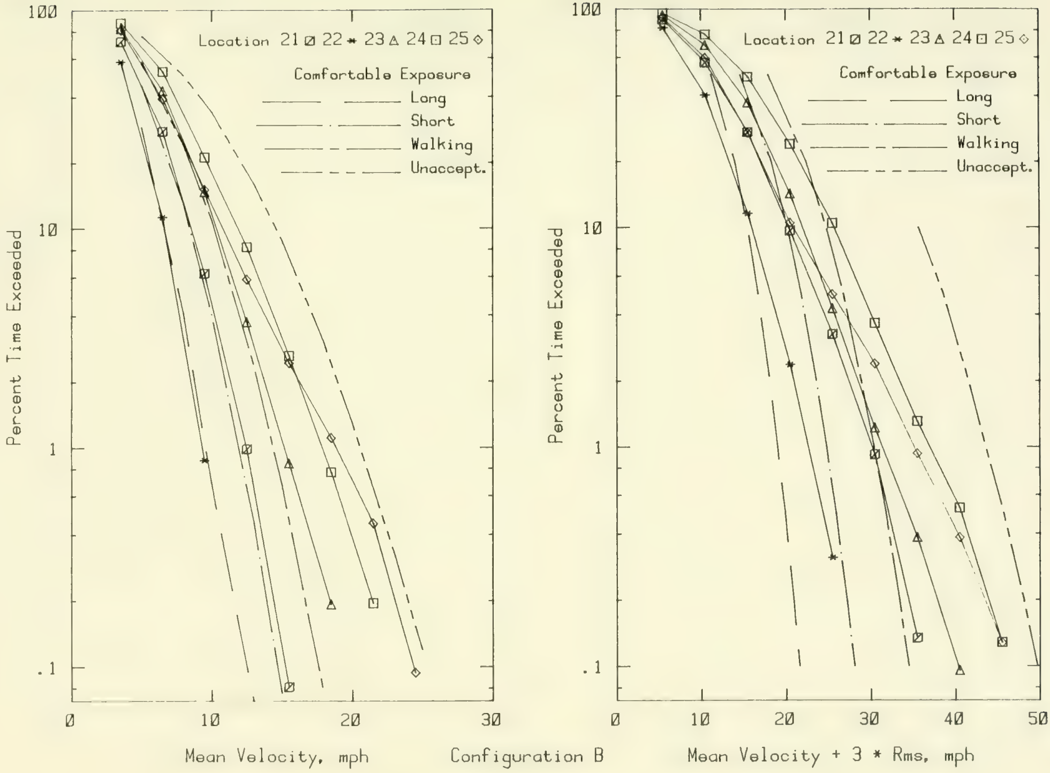


Figure 7m. Wind Velocity Probabilities for Pedestrian Locations

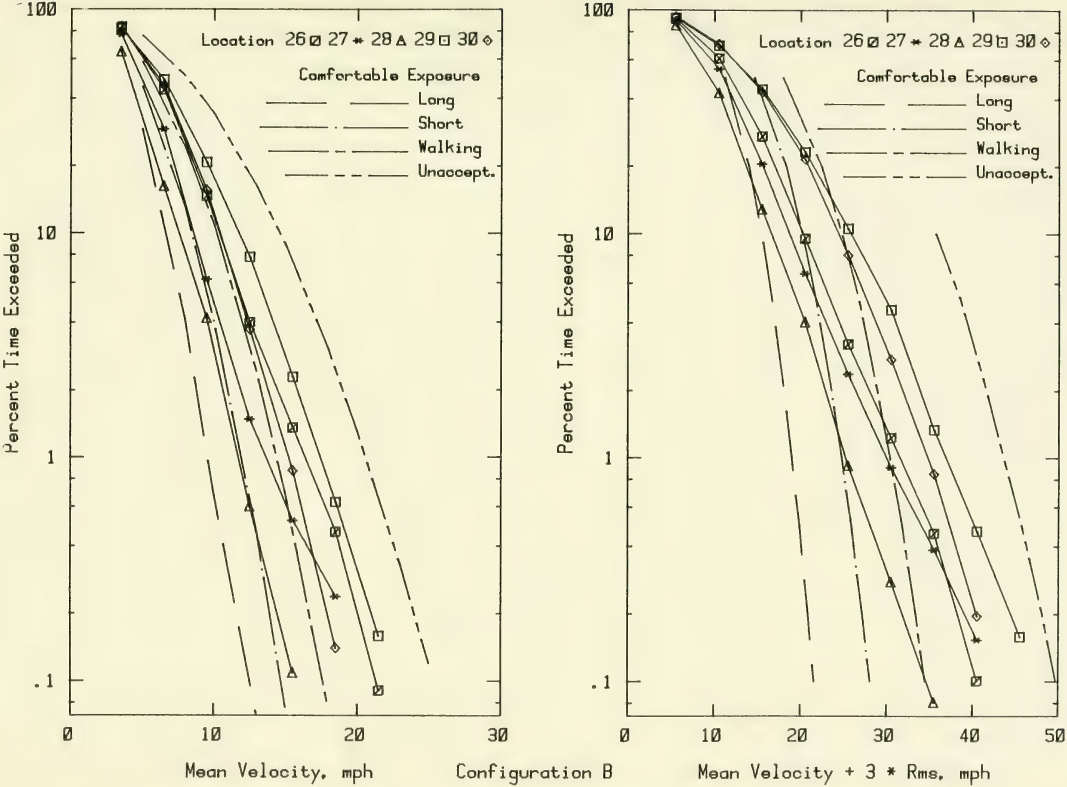
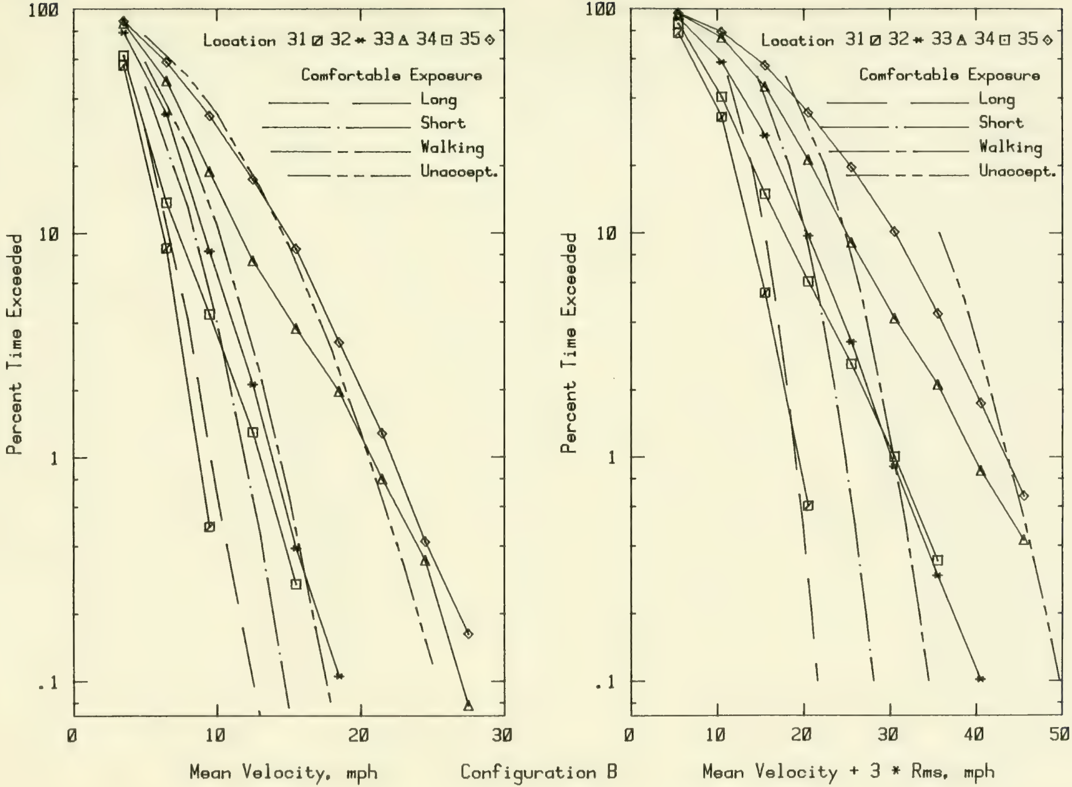


Figure 7n Wind Velocity Probabilities for Pedestrian Locations



Configuration B

Figure 7o Wind Velocity Probabilities for Pedestrian Locations

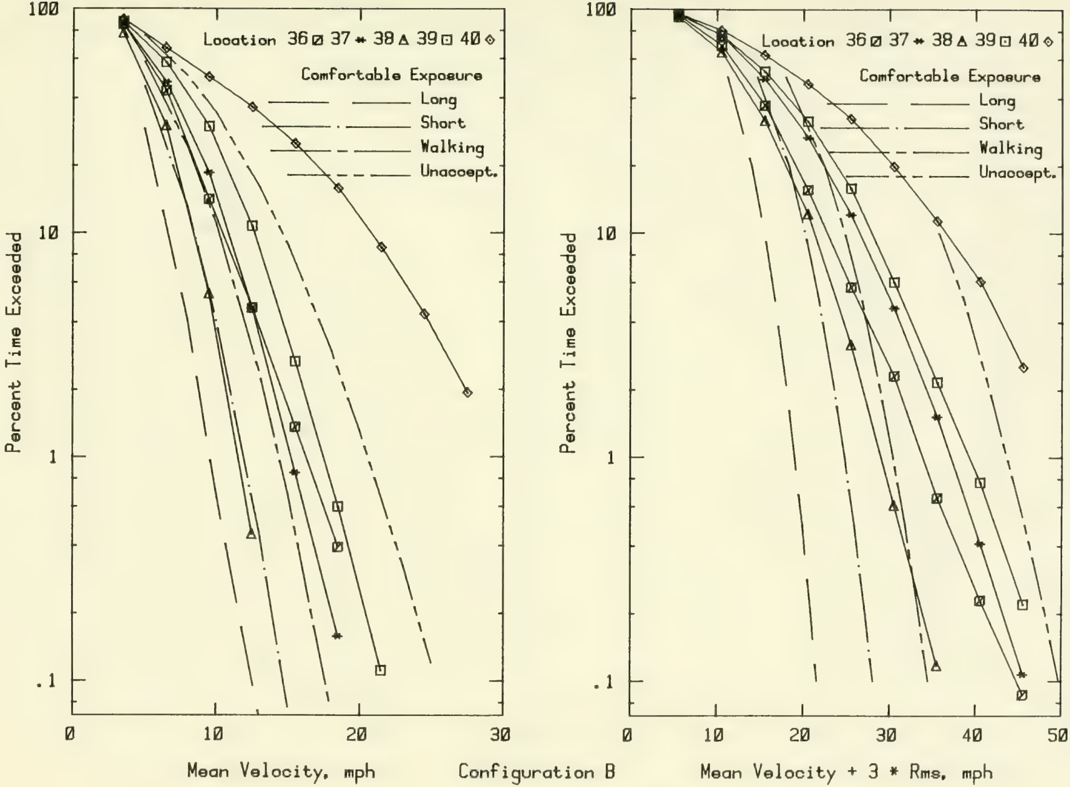


Figure 7p Wind Velocity Probabilities for Pedestrian Locations

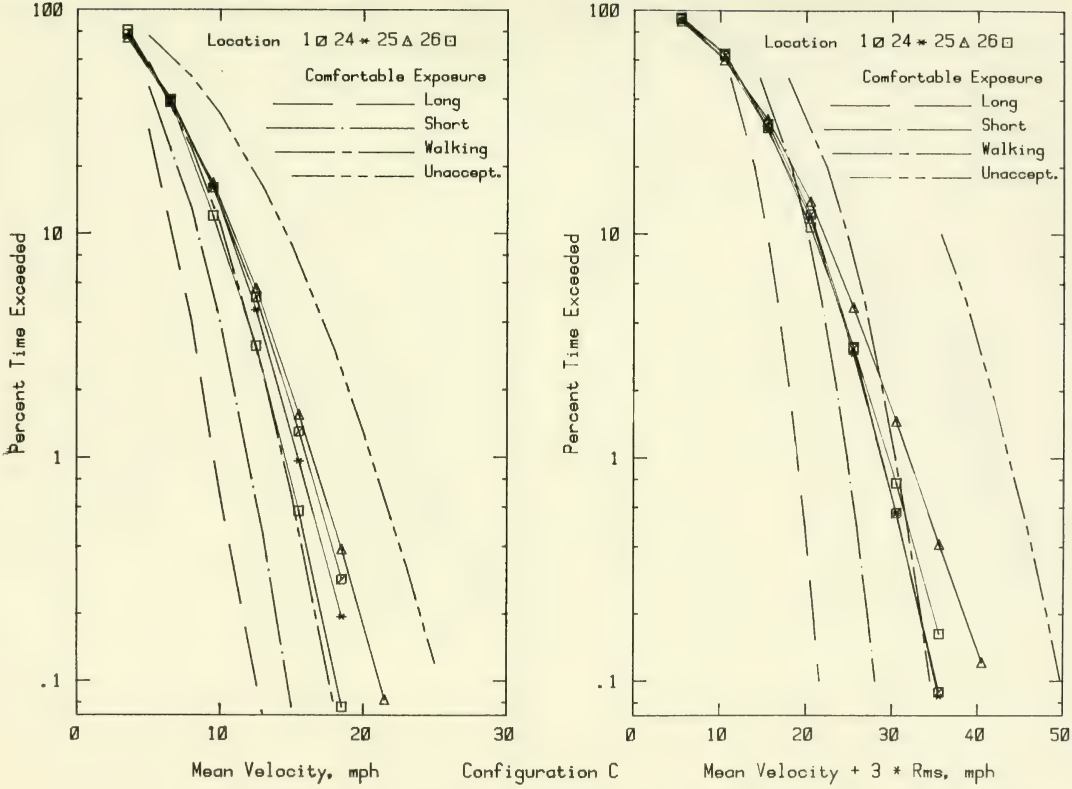


Figure 7q Wind Velocity Probabilities for Pedestrian Locations

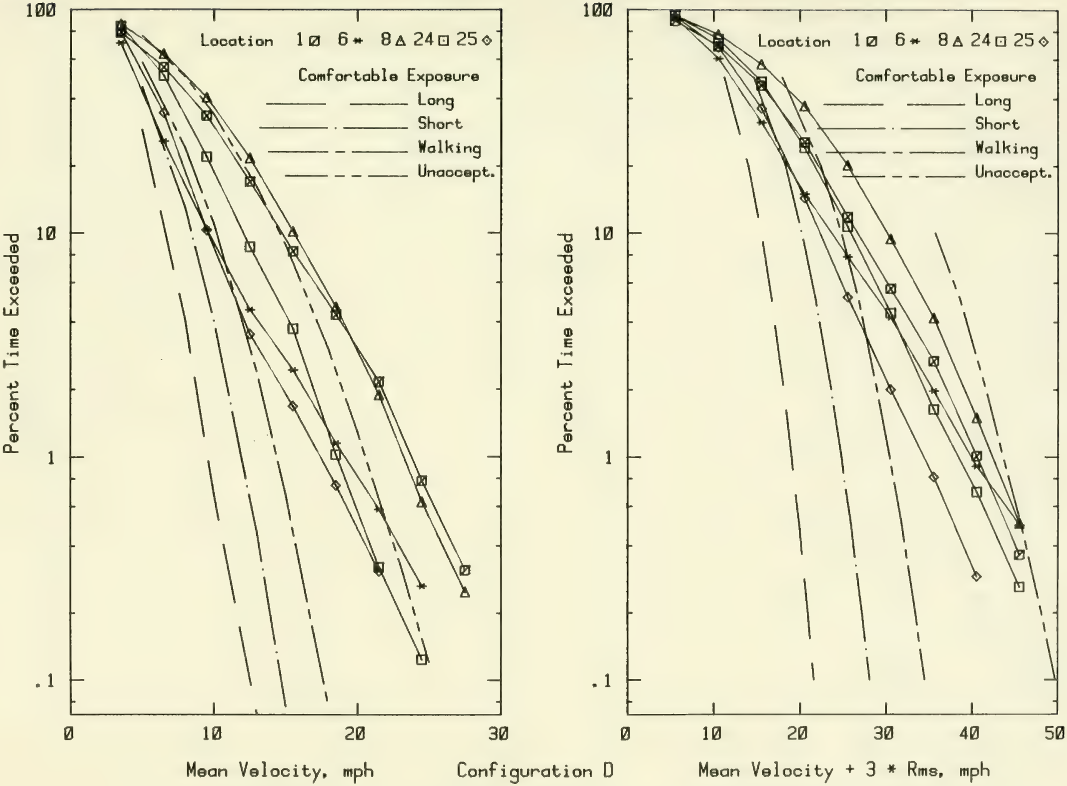


Figure 7r Wind Velocity Probabilities for Pedestriran Locations

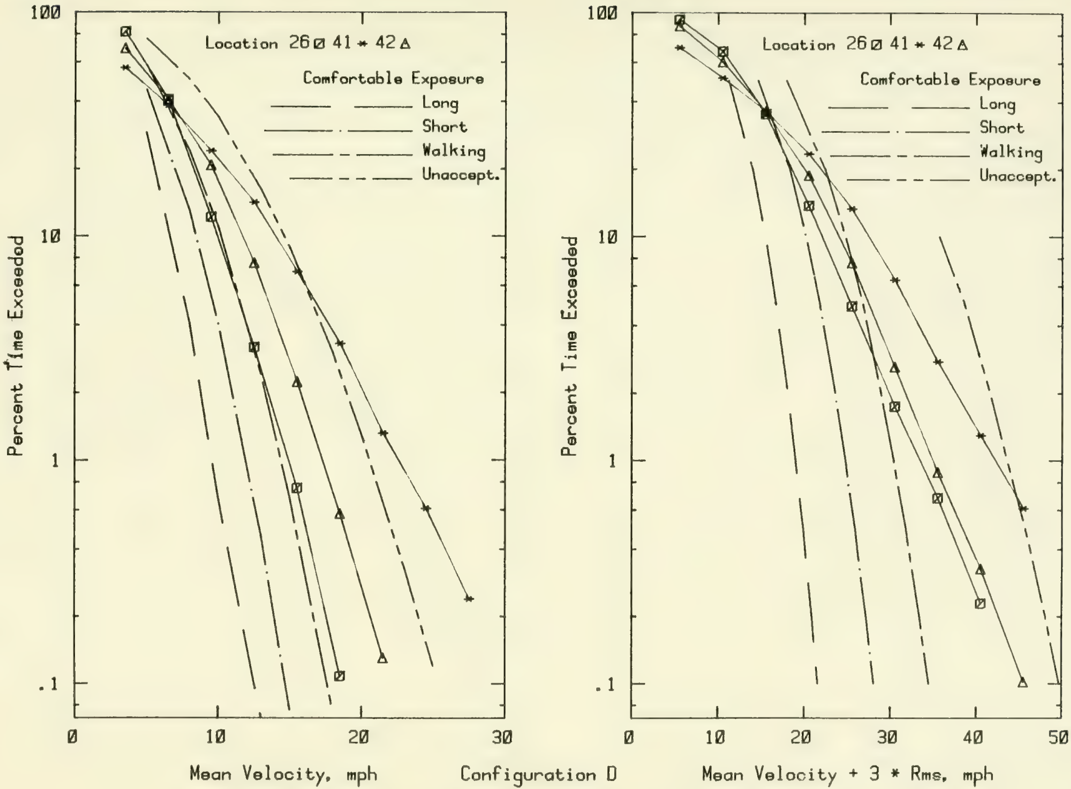


Figure 7s Wind Velocity Probabilities for Pedestrian Locations

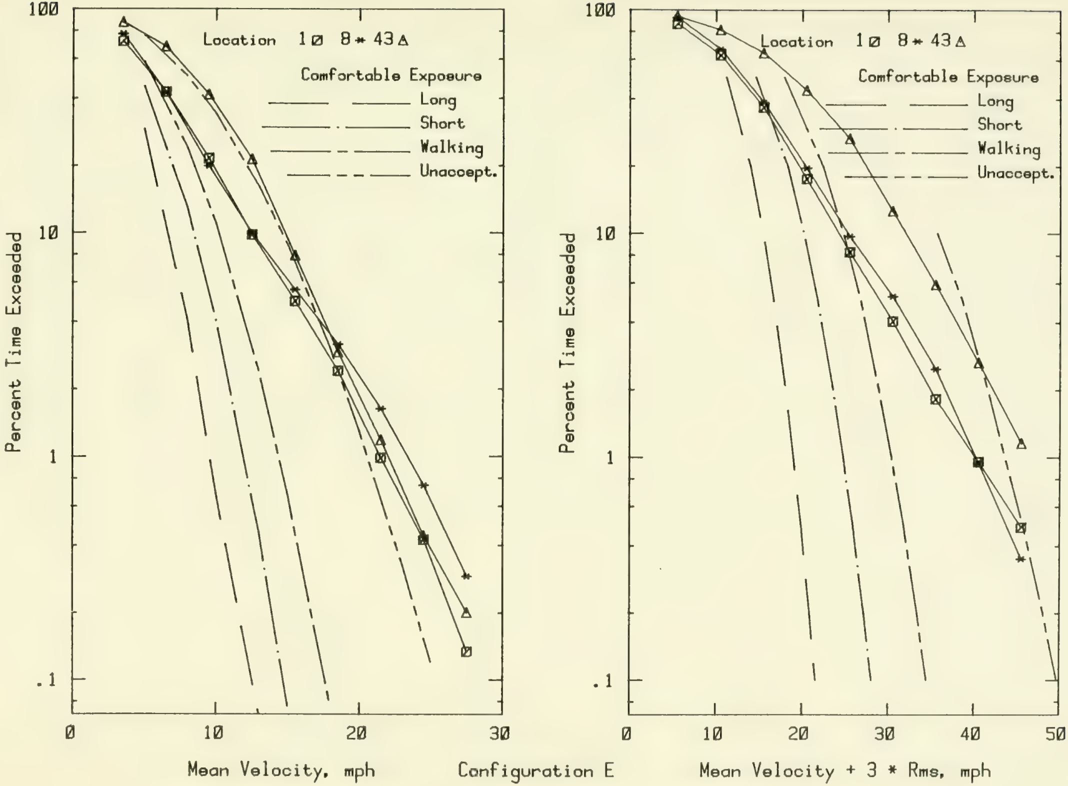


Figure 7t Wind Velocity Probabilities for Pedestrian Locations

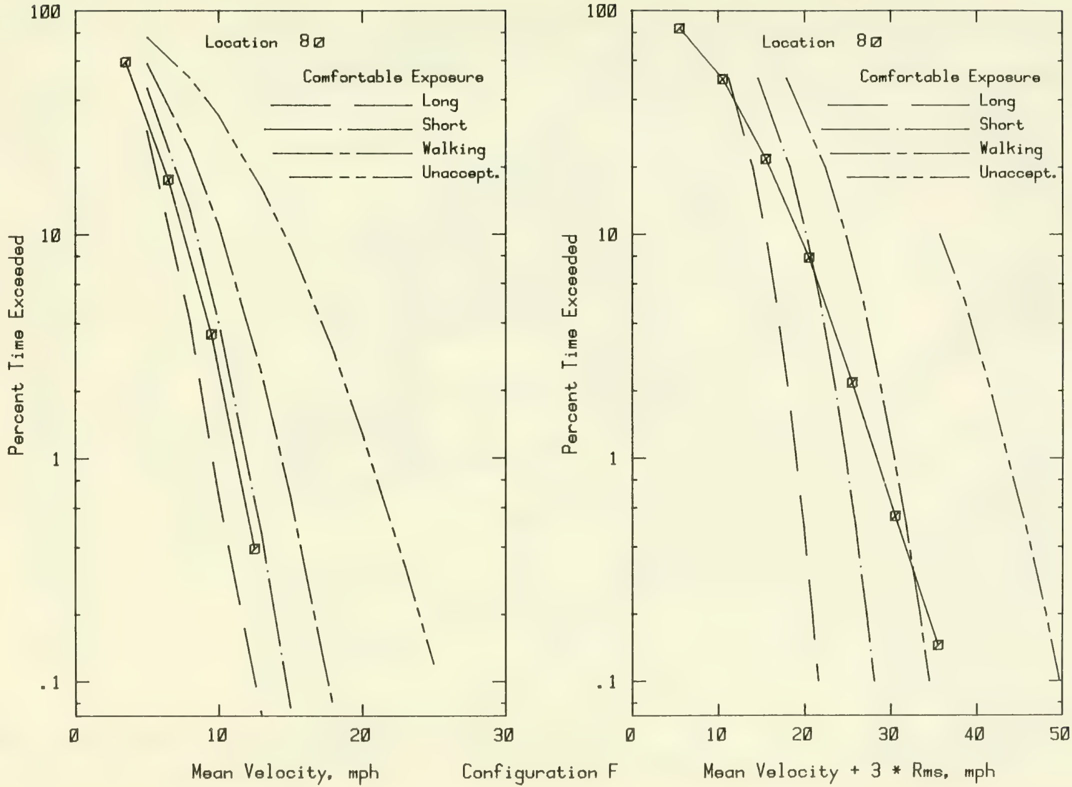


Figure 7u Wind Velocity Probabilities for Pedestrian Locations

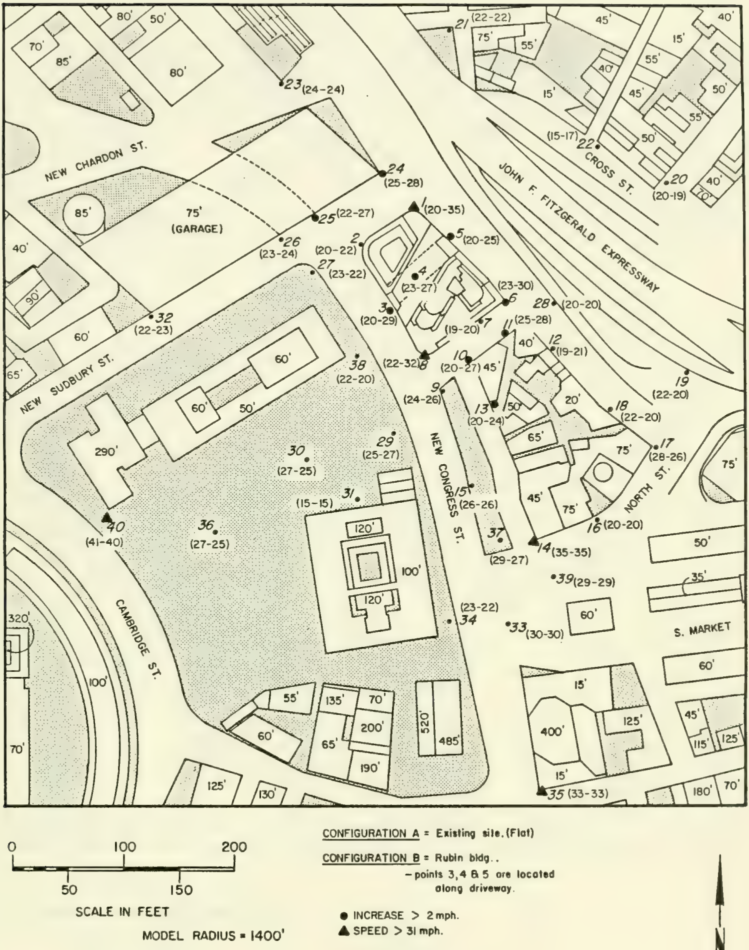


Figure 8 Effective Peak Gusts (mean + 1.5 rms) Wind Speeds Exceeded One Percent of the Time at Measurement Locations for Original Design

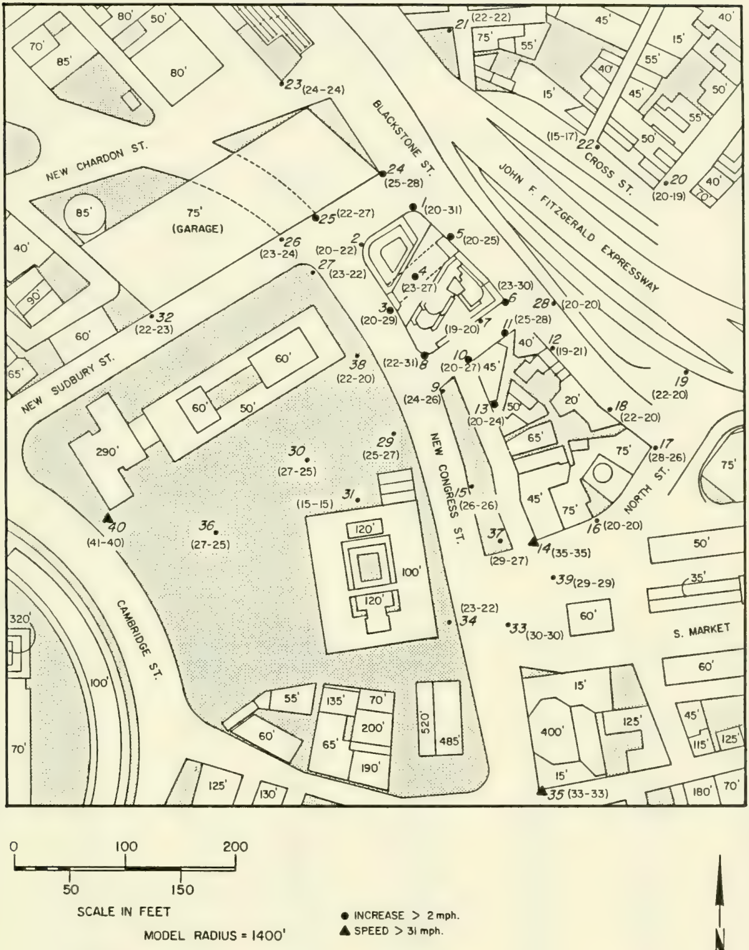


Figure 9 Effective Peak Gusts (mean + 1.5 rms) Wind Speeds Exceeded One Percent of the Time at Measurement Locations for Best Modified Design

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 1

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	33.6	10.7	65.7
22.50	24.3	9.6	53.0
45.00	14.7	5.9	32.4
67.50	19.0	7.4	41.3
90.00	22.6	8.7	48.7
112.50	33.5	10.4	64.7
135.00	33.0	10.9	65.7
157.50	23.6	9.1	50.9
180.00	14.7	5.9	32.5
202.50	20.3	8.5	45.8
225.00	26.9	10.9	59.7
247.50	17.7	7.7	40.6
270.00	15.8	5.8	33.1
292.50	19.6	5.8	37.1
315.00	22.5	6.0	40.5
337.50	29.4	9.4	57.6

LOCATION 2

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	20.2	5.5	36.7
22.50	18.1	6.2	36.7
45.00	22.7	9.2	50.2
67.50	28.1	10.0	58.2
90.00	21.5	10.0	51.5
112.50	32.3	11.8	67.6
135.00	31.8	10.6	63.7
157.50	15.8	6.6	35.5
180.00	14.3	5.9	31.9
202.50	18.2	7.9	41.8
225.00	28.5	12.2	65.0
247.50	17.1	7.3	39.1
270.00	18.6	6.7	38.7
292.50	22.1	6.2	40.8
315.00	19.2	5.5	35.7
337.50	19.5	5.5	36.0

LOCATION 3

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	17.0	5.1	32.3
22.50	21.2	8.1	45.6
45.00	25.3	9.4	53.4
67.50	23.8	11.4	57.9
90.00	23.8	13.0	62.8
112.50	35.8	12.7	73.9
135.00	29.1	9.6	57.9
157.50	15.2	6.1	33.7
180.00	13.3	5.2	28.8
202.50	16.4	7.2	38.1
225.00	20.3	9.0	47.2
247.50	18.9	8.4	44.0
270.00	20.2	7.6	43.0
292.50	20.1	6.7	40.3
315.00	18.6	5.4	34.8
337.50	16.1	5.0	31.0

LOCATION 4

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	26.6	9.0	53.6
22.50	17.6	7.3	39.5
45.00	24.4	10.8	56.7
67.50	31.0	11.1	64.5
90.00	23.1	11.3	56.9
112.50	37.9	15.1	83.2
135.00	34.5	12.1	70.8
157.50	21.4	9.3	49.4
180.00	13.5	5.4	29.8
202.50	20.3	9.1	47.6
225.00	25.2	11.2	58.7
247.50	20.9	9.6	49.8
270.00	19.9	7.7	43.1
292.50	19.9	5.8	37.3
315.00	20.2	5.8	37.7
337.50	21.9	6.2	40.4

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 5

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	31.3	10.3	62.3
22.50	16.4	6.8	36.7
45.00	18.3	7.3	40.2
67.50	25.0	8.7	51.2
90.00	27.2	9.5	55.7
112.50	34.2	10.7	66.4
135.00	29.2	10.7	61.4
157.50	22.2	8.4	47.5
180.00	13.2	4.7	27.5
202.50	18.2	7.9	41.9
225.00	26.8	10.7	58.8
247.50	21.3	8.9	47.9
270.00	19.1	6.9	39.8
292.50	20.1	6.5	39.6
315.00	23.5	6.8	43.9
337.50	28.9	8.9	55.7

LOCATION 6

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	16.5	7.3	38.2
22.50	17.2	7.0	38.1
45.00	25.8	11.3	59.6
67.50	32.6	12.0	68.6
90.00	31.0	12.2	67.7
112.50	37.5	11.8	73.0
135.00	24.1	10.2	54.9
157.50	18.6	7.7	41.6
180.00	13.5	5.5	30.0
202.50	15.9	7.2	37.6
225.00	21.2	7.2	42.7
247.50	26.9	10.4	58.1
270.00	24.1	9.0	51.0
292.50	20.7	6.6	40.6
315.00	20.6	6.9	41.3
337.50	20.9	7.6	43.6

LOCATION 7

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	20.3	7.4	42.3
22.50	20.1	7.3	42.1
45.00	17.2	9.4	45.3
67.50	13.5	8.7	39.5
90.00	14.6	8.4	39.8
112.50	15.2	7.9	38.8
135.00	15.8	6.4	35.0
157.50	12.0	4.6	25.9
180.00	12.4	4.5	25.9
202.50	15.7	6.8	36.0
225.00	17.6	7.0	38.7
247.50	21.3	9.3	49.2
270.00	22.2	10.2	52.9
292.50	19.7	9.1	47.1
315.00	16.8	6.5	36.3
337.50	15.4	6.8	35.7

LOCATION 8

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	24.7	11.3	58.5
22.50	29.5	10.2	60.1
45.00	18.8	9.9	48.4
67.50	16.3	9.8	45.7
90.00	28.3	16.5	77.7
112.50	30.2	13.9	72.0
135.00	31.0	13.7	72.1
157.50	19.8	9.2	47.4
180.00	14.6	6.9	35.2
202.50	20.8	9.4	49.0
225.00	17.7	8.2	42.4
247.50	20.6	9.9	50.1
270.00	22.8	10.7	54.9
292.50	21.1	9.5	49.6
315.00	16.6	7.2	38.2
337.50	18.3	7.8	41.6

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 9

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	24.3	8.2	48.7
22.50	27.0	10.6	58.8
45.00	17.5	11.3	51.4
67.50	23.9	14.0	66.0
90.00	36.4	14.5	79.8
112.50	33.4	14.8	77.8
135.00	24.2	9.1	51.5
157.50	15.9	6.2	34.5
180.00	14.6	5.9	32.3
202.50	15.5	6.4	34.7
225.00	16.0	6.3	35.0
247.50	18.5	8.2	42.9
270.00	20.9	9.2	48.5
292.50	25.6	10.7	57.8
315.00	18.8	7.5	41.4
337.50	20.3	7.3	42.2

LOCATION 10

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	35.1	10.5	66.6
22.50	29.7	12.1	65.9
45.00	12.0	8.1	36.4
67.50	12.9	8.1	37.1
90.00	13.5	7.3	35.4
112.50	15.5	7.3	37.2
135.00	13.4	5.6	30.4
157.50	12.3	5.4	28.4
180.00	12.8	5.9	30.5
202.50	15.2	6.6	35.0
225.00	14.2	6.5	33.8
247.50	18.3	8.8	44.0
270.00	17.4	8.1	41.5
292.50	17.8	8.2	42.4
315.00	17.1	7.8	40.6
337.50	19.8	9.4	47.9

LOCATION 11

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	22.7	7.9	46.4
22.50	17.2	7.5	39.8
45.00	20.9	12.1	57.1
67.50	27.8	12.3	64.7
90.00	37.5	12.7	75.7
112.50	50.0	12.6	87.9
135.00	20.9	8.7	46.9
157.50	13.8	5.7	30.8
180.00	11.9	4.8	26.4
202.50	13.0	5.5	29.4
225.00	14.2	5.5	30.7
247.50	17.8	7.7	40.8
270.00	19.6	8.6	45.4
292.50	18.5	7.3	40.4
315.00	17.9	7.2	39.4
337.50	22.0	7.8	45.5

LOCATION 12

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	17.4	7.7	40.5
22.50	16.1	6.8	36.6
45.00	14.2	7.5	36.8
67.50	17.6	10.0	47.6
90.00	24.0	12.2	60.7
112.50	33.7	12.7	71.9
135.00	31.4	9.9	61.3
157.50	22.6	9.5	51.1
180.00	11.2	4.5	24.6
202.50	11.4	4.7	25.7
225.00	15.6	7.3	37.4
247.50	16.9	8.2	41.4
270.00	12.9	5.4	29.2
292.50	11.6	4.7	25.7
315.00	15.4	6.3	34.2
337.50	19.4	7.4	41.5

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 13

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	14.9	7.2	36.4
22.50	25.2	10.8	57.6
45.00	18.5	10.5	50.0
67.50	13.9	8.3	38.9
90.00	26.6	13.4	66.9
112.50	34.3	13.8	75.9
135.00	13.4	6.0	31.4
157.50	10.4	4.1	22.8
180.00	11.5	4.7	25.7
202.50	14.9	6.2	33.4
225.00	14.4	5.9	32.2
247.50	14.8	6.5	34.2
270.00	17.2	7.4	39.5
292.50	20.2	7.3	42.1
315.00	16.0	6.5	35.5
337.50	13.8	5.8	31.4

LOCATION 14

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	23.4	10.3	54.2
22.50	12.5	5.8	29.9
45.00	17.7	8.8	44.2
67.50	37.3	15.7	84.5
90.00	42.2	10.5	73.9
112.50	42.9	13.0	82.0
135.00	30.5	11.4	64.6
157.50	14.4	6.4	33.7
180.00	25.2	10.9	57.9
202.50	28.1	10.9	60.9
225.00	21.8	8.7	47.8
247.50	34.0	14.2	76.7
270.00	40.7	16.6	90.4
292.50	54.7	16.0	102.5
315.00	43.2	13.3	83.2
337.50	39.0	11.8	74.3

LOCATION 15

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	30.1	10.5	61.6
22.50	21.7	11.4	55.9
45.00	22.6	9.8	51.9
67.50	28.9	12.3	65.8
90.00	31.4	12.3	68.4
112.50	34.0	11.7	69.3
135.00	36.5	12.6	74.3
157.50	23.3	11.9	59.1
180.00	22.1	11.1	55.6
202.50	21.6	11.7	56.8
225.00	17.3	8.1	41.6
247.50	25.7	11.2	59.2
270.00	24.0	11.6	59.0
292.50	38.5	12.2	75.0
315.00	32.4	11.1	65.7
337.50	35.3	10.6	67.0

LOCATION 16

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	18.3	8.1	42.5
22.50	12.9	5.6	29.7
45.00	19.4	8.4	44.7
67.50	21.8	9.3	49.6
90.00	36.7	13.5	77.2
112.50	24.0	10.8	56.2
135.00	21.0	9.9	50.5
157.50	17.7	7.7	40.7
180.00	15.5	7.7	38.5
202.50	18.0	9.6	46.8
225.00	19.1	10.3	50.0
247.50	12.7	5.7	29.7
270.00	14.1	6.4	33.3
292.50	16.7	8.1	41.1
315.00	17.4	8.4	42.6
337.50	20.6	9.2	48.4

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 17

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	36.9	10.9	69.5
22.50	37.9	12.3	74.7
45.00	19.4	8.9	46.0
67.50	23.2	10.3	54.2
90.00	52.4	12.8	90.8
112.50	42.8	15.9	90.6
135.00	48.2	15.0	93.2
157.50	40.9	16.1	89.4
180.00	20.8	8.8	47.3
202.50	26.7	7.2	48.3
225.00	18.6	8.0	42.7
247.50	18.1	8.3	42.9
270.00	18.3	9.3	46.1
292.50	13.6	6.4	32.7
315.00	24.3	10.4	55.5
337.50	35.8	10.2	66.4

LOCATION 18

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	17.3	8.0	41.4
22.50	17.5	8.7	43.5
45.00	19.4	9.0	46.2
67.50	20.3	8.7	46.4
90.00	36.2	14.8	80.5
112.50	27.2	12.2	64.0
135.00	17.7	8.5	43.2
157.50	20.2	11.2	53.1
180.00	12.4	5.5	28.9
202.50	11.5	4.5	24.9
225.00	18.3	7.4	40.5
247.50	18.9	6.8	39.2
270.00	15.8	6.0	33.9
292.50	13.2	5.3	29.1
315.00	20.0	6.9	40.6
337.50	19.7	8.0	43.7

LOCATION 19

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	14.4	6.1	32.8
22.50	16.2	7.9	39.9
45.00	17.2	6.8	37.7
67.50	25.0	10.4	56.3
90.00	30.4	10.7	62.7
112.50	31.1	10.5	62.5
135.00	19.9	8.3	44.9
157.50	19.4	10.8	51.7
180.00	14.7	6.6	34.6
202.50	15.3	6.4	34.6
225.00	22.4	8.6	48.2
247.50	27.2	10.5	58.8
270.00	24.9	9.3	52.8
292.50	25.9	8.9	52.7
315.00	30.1	8.6	55.9
337.50	25.3	7.9	49.0

LOCATION 20

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	12.9	5.9	30.6
22.50	13.1	5.7	30.2
45.00	19.0	10.2	49.8
67.50	22.1	10.6	53.9
90.00	31.6	13.8	73.0
112.50	19.8	11.9	55.6
135.00	16.9	7.1	38.1
157.50	17.9	7.4	40.0
180.00	14.7	6.3	33.5
202.50	10.3	4.4	23.4
225.00	16.0	7.8	39.5
247.50	24.2	11.1	57.5
270.00	13.8	5.9	31.5
292.50	17.6	7.2	39.3
315.00	11.3	4.9	25.9
337.50	11.4	5.1	26.7

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 21

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	22.7	9.2	50.3
22.50	25.6	9.5	53.9
45.00	28.1	11.9	63.8
67.50	17.1	10.4	48.5
90.00	12.2	6.6	32.0
112.50	10.5	5.7	27.7
135.00	18.0	9.6	46.8
157.50	28.8	14.4	72.1
180.00	14.3	6.0	32.3
202.50	18.6	7.7	41.9
225.00	33.1	15.5	79.6
247.50	18.7	9.1	46.0
270.00	20.3	9.7	49.3
292.50	22.3	10.7	54.3
315.00	21.3	8.9	47.9
337.50	23.0	8.9	49.6

LOCATION 22

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	11.3	4.6	25.2
22.50	9.6	3.3	19.6
45.00	8.3	5.1	23.5
67.50	10.0	6.9	30.6
90.00	17.1	8.1	41.5
112.50	21.1	11.0	54.1
135.00	16.1	5.3	32.2
157.50	20.2	7.1	41.3
180.00	14.3	5.6	31.0
202.50	11.6	5.3	27.4
225.00	19.0	9.3	46.8
247.50	14.9	7.4	37.1
270.00	16.6	7.6	39.3
292.50	17.4	8.5	43.0
315.00	15.0	7.7	38.2
337.50	14.3	6.7	34.5

LOCATION 23

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	33.8	11.7	68.9
22.50	39.3	15.1	84.6
45.00	18.7	10.7	50.8
67.50	29.6	12.8	68.0
90.00	35.8	11.4	70.1
112.50	27.6	10.1	57.8
135.00	26.9	8.2	51.6
157.50	19.5	8.0	43.4
180.00	14.6	7.0	35.6
202.50	23.4	10.6	55.3
225.00	25.9	10.6	57.7
247.50	15.6	8.0	39.7
270.00	17.8	8.9	44.6
292.50	25.3	10.7	57.3
315.00	30.8	8.6	56.5
337.50	29.4	8.5	55.0

LOCATION 24

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	44.9	13.1	84.1
22.50	29.6	12.2	66.2
45.00	16.0	6.6	35.8
67.50	18.0	6.5	37.4
90.00	17.1	7.1	38.3
112.50	28.3	9.5	56.7
135.00	38.5	11.4	72.8
157.50	28.8	9.7	58.0
180.00	16.1	7.8	39.5
202.50	22.0	12.2	58.7
225.00	29.0	14.5	72.6
247.50	14.4	6.7	34.5
270.00	15.8	7.3	37.6
292.50	21.6	10.5	53.2
315.00	27.9	13.6	68.9
337.50	39.9	14.9	84.7

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 25

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	36.2	7.8	59.6
22.50	31.8	9.0	58.7
45.00	17.6	6.6	37.3
67.50	28.6	7.8	52.2
90.00	27.0	9.6	55.7
112.50	34.7	10.6	66.5
135.00	29.7	9.0	56.8
157.50	14.4	5.7	31.5
180.00	16.2	7.9	40.0
202.50	19.9	9.7	48.9
225.00	23.2	10.3	54.2
247.50	20.1	7.5	42.7
270.00	25.8	6.6	45.5
292.50	30.3	7.5	52.8
315.00	28.2	5.7	45.1
337.50	29.8	7.7	52.8

LOCATION 26

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	31.1	7.8	54.3
22.50	24.6	8.4	49.1
45.00	21.1	7.6	43.9
67.50	33.8	8.7	60.1
90.00	31.9	11.2	65.4
112.50	41.2	11.4	75.4
135.00	25.6	8.1	50.0
157.50	14.5	5.5	30.9
180.00	17.6	8.8	43.9
202.50	16.5	6.5	36.1
225.00	19.6	8.6	45.5
247.50	18.7	7.1	39.9
270.00	26.7	6.1	44.9
292.50	30.4	5.8	47.9
315.00	27.3	4.6	41.1
337.50	23.4	4.2	36.1

LOCATION 27

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	16.9	5.9	34.6
22.50	13.5	5.5	30.1
45.00	28.5	9.1	55.7
67.50	34.8	8.7	60.9
90.00	32.3	11.9	68.0
112.50	39.9	11.3	73.7
135.00	20.7	7.8	44.0
157.50	13.7	5.1	29.1
180.00	16.2	7.1	37.5
202.50	16.0	6.5	35.6
225.00	25.2	10.5	56.8
247.50	16.1	6.7	36.1
270.00	18.3	6.1	36.5
292.50	19.8	5.5	36.3
315.00	17.0	4.5	30.5
337.50	14.8	3.6	25.5

LOCATION 28

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	15.3	6.2	34.0
22.50	14.3	5.5	30.7
45.00	16.7	6.9	37.5
67.50	19.4	7.6	42.3
90.00	23.1	8.1	47.3
112.50	28.0	9.1	55.4
135.00	19.4	7.1	40.7
157.50	18.4	7.0	39.5
180.00	13.6	5.5	30.1
202.50	13.1	5.5	29.5
225.00	19.2	7.7	42.3
247.50	24.5	10.0	54.5
270.00	26.8	9.0	53.8
292.50	24.0	6.5	43.6
315.00	24.9	6.9	45.7
337.50	21.5	7.7	44.5

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 29

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	19.5	9.0	46.4
22.50	18.5	8.1	42.7
45.00	18.6	10.9	51.3
67.50	26.6	15.3	72.4
90.00	34.8	16.5	84.2
112.50	27.9	16.7	77.8
135.00	23.0	11.0	55.9
157.50	15.6	7.5	38.1
180.00	13.5	4.9	28.3
202.50	14.7	5.9	32.4
225.00	16.9	7.4	39.0
247.50	21.9	8.7	48.0
270.00	21.9	10.4	53.2
292.50	34.4	11.8	69.9
315.00	25.6	10.8	57.8
337.50	23.8	10.1	54.0

LOCATION 30

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	25.7	11.2	59.3
22.50	25.0	8.2	49.6
45.00	37.7	11.3	71.6
67.50	38.1	12.9	76.9
90.00	32.3	11.2	65.9
112.50	28.2	13.7	69.4
135.00	16.2	6.2	34.9
157.50	19.2	7.2	41.0
180.00	17.1	7.3	39.1
202.50	28.1	10.7	60.2
225.00	27.5	13.1	66.9
247.50	29.3	14.6	73.0
270.00	32.7	15.0	77.6
292.50	20.1	8.4	45.4
315.00	21.3	8.9	48.1
337.50	24.2	10.7	56.2

LOCATION 31

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	18.0	8.2	42.5
22.50	23.5	10.1	53.9
45.00	16.7	8.0	40.8
67.50	11.3	6.6	31.2
90.00	14.4	7.1	35.6
112.50	15.1	6.7	35.1
135.00	13.8	4.6	27.5
157.50	10.7	4.0	22.8
180.00	10.5	3.5	21.1
202.50	15.5	5.6	32.1
225.00	14.6	5.1	29.8
247.50	15.4	6.0	33.6
270.00	19.5	6.7	39.5
292.50	14.0	5.2	29.6
315.00	17.0	7.9	40.8
337.50	19.3	9.0	46.2

LOCATION 32

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	15.5	6.4	34.6
22.50	19.2	7.3	41.1
45.00	27.2	9.4	55.4
67.50	31.9	11.2	65.6
90.00	29.7	12.7	67.7
112.50	31.0	13.6	71.8
135.00	25.0	10.6	56.9
157.50	21.5	9.2	49.2
180.00	16.9	7.0	37.9
202.50	19.4	6.3	38.4
225.00	21.0	8.9	47.8
247.50	23.4	10.7	55.4
270.00	24.1	8.7	50.3
292.50	22.2	8.2	46.6
315.00	18.8	6.6	38.6
337.50	22.3	8.6	48.2

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 33

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	21.9	10.5	53.4
22.50	21.4	10.1	51.6
45.00	20.0	9.0	47.0
67.50	21.2	10.4	52.5
90.00	22.5	11.1	55.9
112.50	19.9	10.7	51.9
135.00	28.3	12.9	67.2
157.50	35.9	14.2	78.5
180.00	44.3	12.7	82.3
202.50	58.3	16.7	108.5
225.00	35.4	11.3	69.2
247.50	19.6	8.6	45.3
270.00	23.3	10.4	54.6
292.50	22.4	11.0	55.5
315.00	28.4	14.0	70.6
337.50	25.7	11.9	61.4

LOCATION 34

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	18.5	10.4	49.8
22.50	33.6	16.7	83.7
45.00	32.4	13.7	73.5
67.50	33.1	11.1	66.2
90.00	26.8	13.6	67.6
112.50	17.4	9.4	45.6
135.00	22.2	10.6	54.1
157.50	21.7	11.2	55.4
180.00	17.4	7.7	40.4
202.50	17.1	7.8	40.4
225.00	14.6	5.8	32.0
247.50	11.9	5.0	26.9
270.00	14.3	6.7	34.4
292.50	12.8	5.7	29.8
315.00	12.4	5.0	27.5
337.50	14.0	7.7	37.0

LOCATION 35

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	49.8	15.6	96.6
22.50	30.5	16.2	79.0
45.00	18.7	11.1	52.0
67.50	16.4	9.6	45.1
90.00	19.7	12.2	56.5
112.50	38.3	14.8	82.7
135.00	43.2	17.3	95.1
157.50	44.9	18.3	100.0
180.00	36.7	15.3	82.4
202.50	36.3	14.3	79.2
225.00	40.4	16.2	89.0
247.50	22.4	10.2	52.9
270.00	14.3	6.0	32.1
292.50	26.6	10.2	57.1
315.00	52.4	16.6	102.1
337.50	50.1	14.2	92.8

LOCATION 36

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	33.8	11.2	67.4
22.50	38.2	10.4	69.3
45.00	42.6	10.9	75.3
67.50	32.3	12.3	69.4
90.00	44.4	15.4	90.6
112.50	27.8	13.1	67.0
135.00	18.3	6.4	37.4
157.50	23.0	8.8	49.6
180.00	18.9	8.1	43.4
202.50	23.3	10.9	56.1
225.00	19.9	8.5	45.5
247.50	20.8	8.6	46.5
270.00	21.0	9.9	50.6
292.50	23.3	9.6	52.2
315.00	20.0	7.5	42.6
337.50	23.0	9.8	52.4

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

LOCATION 37

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	26.4	11.7	61.4
22.50	18.9	9.8	48.4
45.00	15.2	7.7	38.4
67.50	20.1	9.6	48.9
90.00	24.4	11.5	58.9
112.50	31.5	13.2	71.0
135.00	24.7	10.8	57.0
157.50	29.6	14.6	73.3
180.00	27.7	14.2	70.2
202.50	38.7	18.4	94.0
225.00	17.9	9.0	44.9
247.50	31.5	13.8	72.9
270.00	34.1	14.3	77.0
292.50	33.0	15.1	78.3
315.00	24.0	11.5	58.4
337.50	28.7	12.8	67.2

LOCATION 38

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	23.5	9.2	51.1
22.50	31.3	11.7	66.4
45.00	35.4	13.8	76.7
67.50	22.2	13.3	62.1
90.00	24.7	11.7	59.9
112.50	22.9	11.7	58.0
135.00	23.1	8.7	49.3
157.50	15.5	6.2	33.9
180.00	15.7	6.5	35.2
202.50	21.4	10.5	52.9
225.00	17.2	7.7	40.4
247.50	18.7	8.1	43.0
270.00	20.7	9.6	49.3
292.50	18.8	7.8	42.2
315.00	13.9	5.1	29.2
337.50	16.0	6.4	35.1

LOCATION 39

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	17.7	8.3	42.5
22.50	18.2	9.1	45.4
45.00	18.1	9.5	46.5
67.50	28.4	10.8	60.9
90.00	33.3	12.3	70.2
112.50	32.4	12.5	69.9
135.00	23.7	9.9	53.3
157.50	16.5	7.1	37.7
180.00	32.4	14.8	76.9
202.50	37.0	15.8	84.4
225.00	30.8	10.2	61.5
247.50	31.3	13.6	72.3
270.00	36.0	15.7	83.0
292.50	34.8	13.6	75.7
315.00	28.7	10.7	60.9
337.50	25.8	11.0	58.7

LOCATION 40

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	24.1	11.0	57.2
22.50	22.3	9.6	51.1
45.00	35.0	18.8	91.3
67.50	44.1	18.3	98.9
90.00	55.9	22.5	123.5
112.50	18.3	11.2	51.9
135.00	20.4	7.6	43.2
157.50	24.4	9.1	51.7
180.00	22.3	8.9	48.9
202.50	17.1	6.9	37.9
225.00	32.6	14.6	76.4
247.50	63.7	15.3	109.6
270.00	62.9	13.0	102.0
292.50	58.7	12.5	96.1
315.00	45.4	11.8	80.8
337.50	40.0	13.1	79.4

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration A - Existing site w/ city model

* * GREATEST VALUES * *

U/UR (PERCENT)					URMS/UR (PERCENT)					U+3*URMS /UR (PERCENT)				
LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS
40	247.5	63.7	15.3	109.6	40	90.0	55.9	22.5	123.5	40	90.0	55.9	22.5	123.5
40	270.0	62.9	13.0	102.0	40	45.0	35.0	18.8	91.3	40	247.5	63.7	15.3	109.6
40	292.5	58.7	12.5	96.1	37	202.5	38.7	18.4	94.0	33	202.5	58.3	16.7	108.5
33	202.5	58.3	16.7	108.5	35	157.5	44.9	18.3	100.0	14	292.5	54.7	16.0	102.5
40	90.0	55.9	22.5	123.5	40	67.5	44.1	18.3	98.9	35	315.0	52.4	16.6	102.1
14	292.5	54.7	16.0	102.5	35	135.0	43.2	17.3	95.1	40	270.0	62.9	13.0	102.0
17	90.0	52.4	12.8	90.8	33	202.5	58.3	16.7	108.5	35	157.5	44.9	18.3	100.0
35	315.0	52.4	16.6	102.1	34	22.5	33.6	16.7	83.7	40	67.5	44.1	18.3	98.9
35	337.5	50.1	14.2	92.8	29	112.5	27.9	16.7	77.8	35	0.0	49.8	15.6	96.6
11	112.5	50.0	12.6	87.9	35	315.0	52.4	16.6	102.1	40	292.5	58.7	12.5	96.1
35	0.0	49.8	15.6	96.6	14	270.0	40.7	16.6	90.4	35	135.0	43.2	17.3	95.1
17	135.0	48.2	15.0	93.2	8	90.0	28.3	16.5	77.7	37	202.5	38.7	18.4	94.0
40	315.0	45.4	11.8	80.8	29	90.0	34.8	16.5	84.2	17	135.0	48.2	15.0	93.2
35	157.5	44.9	18.3	100.0	35	225.0	40.4	16.2	89.0	35	337.5	50.1	14.2	92.8
24	0.0	44.9	13.1	84.1	35	22.5	30.5	16.2	79.0	40	45.0	35.0	18.8	91.3

TYPICAL VALUES FOR AN OPEN-COUNTRY SITE :

U/UR = 45-50 PERCENT
URMS/UR = 10-12 PERCENT
U+3*URMS/UR = 75-85 PERCENT

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 1

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	19.3	7.3	41.3
22.50	24.8	11.9	60.5
45.00	54.6	19.4	112.7
67.50	65.6	14.3	108.4
90.00	61.1	12.4	98.3
112.50	56.3	11.5	90.8
135.00	38.0	14.8	82.4
157.50	17.9	9.0	44.9
180.00	12.4	4.8	26.7
202.50	15.3	6.4	34.6
225.00	25.3	11.3	59.1
247.50	28.0	9.6	56.8
270.00	35.8	9.2	63.5
292.50	39.6	10.0	69.5
315.00	41.7	9.8	71.1
337.50	31.0	11.9	66.8

LOCATION 2

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	40.5	11.1	74.0
22.50	29.9	13.1	69.3
45.00	14.8	10.0	44.6
67.50	12.2	6.9	33.0
90.00	14.6	8.2	39.1
112.50	19.9	10.2	50.6
135.00	16.0	6.2	34.7
157.50	11.4	3.7	22.5
180.00	11.4	4.2	24.0
202.50	20.2	8.4	45.3
225.00	19.3	6.9	40.0
247.50	18.1	7.8	41.4
270.00	14.8	5.3	30.8
292.50	14.7	5.4	31.0
315.00	23.7	8.7	49.8
337.50	36.4	9.6	65.3

LOCATION 3

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	19.1	7.6	41.9
22.50	35.7	9.5	64.1
45.00	40.3	11.3	74.3
67.50	45.4	12.5	83.0
90.00	41.7	13.5	82.2
112.50	23.3	11.7	58.5
135.00	19.6	7.1	40.8
157.50	12.2	4.0	24.0
180.00	11.6	3.5	22.2
202.50	16.5	6.5	35.9
225.00	26.2	11.6	60.9
247.50	22.7	10.1	53.0
270.00	31.8	10.9	64.6
292.50	31.8	10.2	62.3
315.00	42.8	10.9	75.5
337.50	28.0	12.2	64.6

LOCATION 4

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	15.0	5.5	31.5
22.50	18.8	6.3	37.8
45.00	42.9	13.5	83.5
67.50	46.1	13.5	86.7
90.00	44.4	12.2	81.0
112.50	32.9	12.1	69.2
135.00	15.5	6.2	34.0
157.50	8.6	3.0	17.1
180.00	7.7	2.3	14.5
202.50	16.0	6.2	34.5
225.00	18.1	4.9	32.7
247.50	20.1	5.8	37.6
270.00	19.6	5.5	36.2
292.50	14.9	4.2	27.6
315.00	14.0	3.9	25.7
337.50	8.6	2.5	16.1

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 5

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	31.0	12.4	68.1
22.50	23.9	9.4	52.1
45.00	26.4	11.2	59.8
67.50	33.0	12.2	69.7
90.00	34.9	11.7	70.0
112.50	41.2	10.5	72.7
135.00	28.2	11.5	62.7
157.50	17.2	6.9	37.9
180.00	11.6	3.8	23.2
202.50	15.6	6.5	35.1
225.00	19.9	7.7	43.0
247.50	18.6	7.5	41.2
270.00	19.1	7.5	41.5
292.50	21.0	10.0	51.1
315.00	33.6	14.4	76.8
337.50	28.6	11.7	63.6

LOCATION 6

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	50.3	13.5	90.9
22.50	51.3	15.2	97.0
45.00	46.0	16.5	95.4
67.50	34.1	13.4	74.3
90.00	17.4	9.0	44.3
112.50	24.3	13.3	64.1
135.00	41.5	14.6	85.4
157.50	28.3	10.5	59.7
180.00	19.6	9.0	46.6
202.50	23.2	10.2	53.9
225.00	16.4	8.2	41.0
247.50	22.6	10.9	55.2
270.00	19.8	9.7	49.0
292.50	13.8	6.3	32.8
315.00	16.4	9.3	44.2
337.50	47.2	12.4	84.4

LOCATION 7

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	18.8	8.3	43.6
22.50	23.2	10.0	53.2
45.00	26.8	10.0	56.8
67.50	30.6	8.5	56.2
90.00	31.4	9.5	60.0
112.50	21.4	9.6	50.2
135.00	22.8	10.0	52.6
157.50	14.7	6.9	35.2
180.00	12.2	5.6	29.1
202.50	16.6	6.8	37.1
225.00	13.9	5.8	31.2
247.50	20.0	8.6	45.9
270.00	18.2	8.6	44.1
292.50	15.2	6.7	35.4
315.00	13.0	5.2	28.6
337.50	15.3	5.9	32.9

LOCATION 8

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	34.9	13.4	75.2
22.50	17.0	7.3	38.9
45.00	25.1	13.3	65.1
67.50	37.0	14.1	79.2
90.00	47.2	13.1	86.6
112.50	58.5	11.3	92.4
135.00	44.5	16.3	93.3
157.50	19.4	9.1	46.5
180.00	13.5	5.6	30.4
202.50	17.2	8.1	41.7
225.00	26.7	12.4	63.9
247.50	31.8	14.2	74.5
270.00	44.3	14.6	88.0
292.50	38.1	10.7	70.1
315.00	34.9	13.7	76.1
337.50	38.1	12.6	75.8

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 9

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	32.2	12.3	69.2
22.50	19.7	9.3	47.7
45.00	24.6	14.7	68.8
67.50	24.7	13.6	65.6
90.00	27.6	14.0	69.5
112.50	35.3	16.3	84.0
135.00	35.5	13.7	76.6
157.50	18.2	8.4	43.4
180.00	14.7	5.5	31.3
202.50	16.0	6.8	36.4
225.00	27.0	11.8	62.5
247.50	28.3	12.5	65.7
270.00	34.8	13.9	76.4
292.50	28.7	8.8	55.0
315.00	26.2	10.1	56.6
337.50	31.3	12.4	68.5

LOCATION 10

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	24.3	7.7	47.3
22.50	27.4	14.6	71.1
45.00	30.3	17.8	83.7
67.50	35.6	14.2	78.1
90.00	39.8	13.7	80.9
112.50	48.0	12.4	85.1
135.00	38.7	13.3	78.7
157.50	17.5	9.0	44.5
180.00	13.0	5.5	29.6
202.50	14.8	6.1	33.2
225.00	16.8	6.6	36.5
247.50	22.7	9.3	50.6
270.00	27.2	10.0	57.2
292.50	26.2	7.5	48.5
315.00	23.2	7.5	45.7
337.50	24.2	7.8	47.5

LOCATION 11

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	41.0	14.9	85.6
22.50	39.2	17.0	90.1
45.00	39.5	17.9	93.1
67.50	40.9	15.9	88.7
90.00	25.7	13.2	65.4
112.50	32.1	13.9	73.7
135.00	36.5	14.0	78.5
157.50	17.9	8.1	42.2
180.00	13.8	5.7	30.8
202.50	14.8	6.3	33.9
225.00	15.0	6.5	34.7
247.50	18.8	9.0	45.7
270.00	16.2	7.3	38.2
292.50	13.4	5.4	29.6
315.00	12.6	5.0	27.6
337.50	32.1	15.9	79.7

LOCATION 12

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	37.5	12.9	76.3
22.50	27.0	15.1	72.2
45.00	12.5	7.4	34.8
67.50	14.6	8.6	40.3
90.00	16.2	9.8	45.7
112.50	24.4	11.6	59.3
135.00	25.9	9.5	54.5
157.50	21.3	9.6	50.2
180.00	11.5	5.0	26.5
202.50	10.3	3.8	21.7
225.00	18.4	8.9	45.0
247.50	13.1	5.9	30.7
270.00	12.1	4.6	26.0
292.50	9.3	3.5	19.9
315.00	13.0	7.0	34.1
337.50	32.0	11.2	65.6

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 13

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	14.0	6.1	32.3
22.50	30.4	16.4	79.5
45.00	30.1	19.0	87.1
67.50	19.5	11.3	53.3
90.00	32.2	11.1	65.5
112.50	35.0	12.7	73.2
135.00	17.6	7.4	39.8
157.50	11.5	5.1	26.8
180.00	11.4	4.7	25.5
202.50	13.7	5.6	30.5
225.00	17.3	7.7	40.4
247.50	18.4	8.5	43.9
270.00	19.0	8.0	42.9
292.50	21.2	7.5	43.8
315.00	15.4	6.3	34.4
337.50	15.2	5.8	32.7

LOCATION 14

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	25.5	10.3	56.3
22.50	11.9	4.8	26.1
45.00	20.5	8.6	46.2
67.50	34.1	13.6	74.9
90.00	40.9	10.1	71.3
112.50	41.9	13.9	83.7
135.00	29.3	11.3	63.2
157.50	14.6	6.7	34.7
180.00	24.2	10.7	56.3
202.50	26.6	10.3	57.5
225.00	26.1	11.2	59.7
247.50	32.4	15.0	77.4
270.00	38.5	15.9	86.3
292.50	53.1	16.4	102.3
315.00	34.0	12.0	69.9
337.50	36.7	12.1	73.1

LOCATION 15

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	25.5	10.1	55.7
22.50	20.0	9.3	47.8
45.00	24.9	11.8	60.4
67.50	30.6	12.3	67.6
90.00	29.2	12.4	66.3
112.50	30.9	11.7	65.9
135.00	30.5	12.4	67.7
157.50	23.9	12.0	59.8
180.00	20.7	11.2	54.1
202.50	21.3	11.7	56.4
225.00	16.2	8.0	40.2
247.50	25.6	11.6	60.4
270.00	24.9	12.6	62.6
292.50	39.2	11.6	74.0
315.00	29.4	10.2	60.0
337.50	31.2	11.1	64.4

LOCATION 16

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	20.4	8.7	46.5
22.50	13.8	6.1	32.0
45.00	20.1	8.7	46.2
67.50	21.1	8.6	46.1
90.00	36.6	13.0	75.5
112.50	21.9	10.2	52.4
135.00	20.5	9.6	49.4
157.50	18.5	8.3	43.4
180.00	16.2	7.8	39.5
202.50	19.1	10.6	50.8
225.00	15.2	8.1	39.4
247.50	12.5	5.3	28.5
270.00	15.2	7.4	37.4
292.50	18.0	8.7	44.1
315.00	18.6	8.3	43.5
337.50	21.4	9.1	48.8

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 17

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	36.4	9.5	65.0
22.50	36.7	10.9	69.3
45.00	21.2	9.7	50.1
67.50	22.0	9.8	51.5
90.00	47.0	14.3	89.9
112.50	39.0	15.5	85.4
135.00	45.5	15.4	91.6
157.50	38.5	15.8	86.0
180.00	19.7	8.8	46.1
202.50	24.4	7.3	46.2
225.00	16.0	7.9	39.7
247.50	16.9	7.9	40.8
270.00	17.5	8.8	43.9
292.50	13.4	6.2	32.0
315.00	21.3	9.7	50.3
337.50	35.3	10.4	66.5

LOCATION 18

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	22.0	10.5	53.4
22.50	19.8	10.3	50.7
45.00	17.9	8.2	42.3
67.50	20.2	8.1	44.4
90.00	31.4	14.6	75.1
112.50	25.6	11.7	60.8
135.00	16.0	7.6	38.9
157.50	18.5	9.9	48.1
180.00	12.4	5.3	28.4
202.50	10.6	4.3	23.4
225.00	14.5	6.6	34.2
247.50	16.7	6.8	37.2
270.00	14.8	6.5	34.1
292.50	11.9	4.8	26.3
315.00	16.4	6.1	34.7
337.50	20.3	8.9	47.1

LOCATION 19

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	17.5	6.8	37.8
22.50	18.4	8.3	43.4
45.00	16.2	6.3	35.3
67.50	22.4	9.7	51.4
90.00	28.0	10.9	60.8
112.50	27.9	9.8	57.4
135.00	18.4	8.2	43.0
157.50	21.9	11.5	56.4
180.00	14.7	6.5	34.2
202.50	15.7	6.3	34.4
225.00	21.7	8.6	47.5
247.50	26.0	11.9	61.6
270.00	24.9	10.4	56.2
292.50	17.7	7.2	39.4
315.00	23.7	9.3	51.7
337.50	24.4	8.2	48.8

LOCATION 20

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	13.0	6.2	31.5
22.50	10.4	4.6	24.1
45.00	15.1	10.1	45.4
67.50	19.8	10.3	50.8
90.00	26.5	13.4	66.8
112.50	17.2	10.2	47.7
135.00	16.6	6.8	37.1
157.50	17.9	7.4	40.1
180.00	15.1	6.4	34.3
202.50	10.3	3.9	22.0
225.00	13.7	6.2	32.3
247.50	20.5	9.1	47.9
270.00	13.8	5.8	31.3
292.50	17.8	7.7	41.1
315.00	12.8	5.7	29.9
337.50	12.3	5.2	27.9

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 21

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	22.7	9.5	51.1
22.50	22.3	9.2	50.0
45.00	26.3	12.3	63.3
67.50	15.1	9.3	42.9
90.00	13.1	6.9	33.9
112.50	10.8	5.4	27.1
135.00	15.2	7.8	38.6
157.50	28.3	14.2	70.8
180.00	14.7	6.4	33.9
202.50	19.0	8.4	44.3
225.00	31.9	15.2	77.6
247.50	17.1	7.9	40.7
270.00	20.2	9.8	49.5
292.50	22.9	10.7	55.0
315.00	20.5	8.6	46.1
337.50	22.4	9.0	49.3

LOCATION 22

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	13.2	5.5	29.8
22.50	11.2	4.4	24.3
45.00	8.8	5.0	23.7
67.50	11.7	7.7	34.9
90.00	20.5	7.8	43.9
112.50	24.7	11.6	59.5
135.00	16.5	5.9	34.1
157.50	18.7	6.6	38.4
180.00	14.4	5.7	31.6
202.50	10.4	4.5	24.1
225.00	19.3	10.0	49.2
247.50	14.6	6.9	35.3
270.00	16.6	7.3	38.5
292.50	17.0	8.2	41.6
315.00	16.1	8.0	40.0
337.50	15.9	7.8	39.2

LOCATION 23

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	30.1	10.8	62.4
22.50	39.1	14.5	82.6
45.00	18.2	10.0	48.1
67.50	34.6	13.4	74.6
90.00	36.0	10.8	68.4
112.50	29.0	9.9	58.5
135.00	24.8	8.5	50.3
157.50	20.6	8.5	46.1
180.00	13.9	6.8	34.3
202.50	22.6	9.2	50.3
225.00	25.9	10.8	58.4
247.50	16.4	8.2	41.1
270.00	18.9	10.1	49.3
292.50	22.2	10.1	52.5
315.00	27.7	9.5	56.3
337.50	29.9	8.4	55.0

LOCATION 24

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	35.2	13.6	75.9
22.50	20.4	10.4	51.7
45.00	34.3	14.4	77.6
67.50	45.9	16.2	94.5
90.00	40.3	12.9	79.1
112.50	40.9	11.3	74.9
135.00	31.6	13.5	72.2
157.50	20.3	9.6	49.1
180.00	16.7	8.2	41.4
202.50	24.0	10.3	54.9
225.00	36.0	14.1	78.3
247.50	21.3	11.4	55.3
270.00	21.7	8.7	48.8
292.50	22.9	10.3	53.1
315.00	25.7	12.2	62.3
337.50	24.7	11.4	58.9

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 25

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	33.2	5.9	50.8
22.50	32.9	7.5	55.4
45.00	43.1	10.8	75.7
67.50	51.0	12.9	89.6
90.00	38.5	16.0	86.5
112.50	16.1	7.8	39.5
135.00	23.3	9.7	52.5
157.50	14.1	5.2	29.7
180.00	16.7	7.4	38.8
202.50	25.0	9.5	53.4
225.00	27.9	9.9	57.5
247.50	17.7	7.7	40.9
270.00	17.1	7.4	39.2
292.50	20.8	7.5	43.2
315.00	19.2	6.0	37.1
337.50	29.8	7.6	52.5

LOCATION 26

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	29.1	8.1	53.5
22.50	27.5	7.1	48.7
45.00	37.0	11.8	72.3
67.50	44.7	12.4	81.9
90.00	23.9	13.7	64.9
112.50	24.5	14.6	68.3
135.00	30.7	11.5	65.1
157.50	13.4	4.9	28.2
180.00	18.6	9.3	46.4
202.50	17.4	7.1	38.5
225.00	20.6	8.7	46.6
247.50	17.2	6.2	35.9
270.00	23.8	7.0	44.7
292.50	27.6	5.9	45.2
315.00	25.8	4.6	39.4
337.50	29.0	7.2	50.7

LOCATION 27

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	22.5	8.2	47.0
22.50	22.2	8.4	47.5
45.00	40.1	13.6	81.0
67.50	27.6	13.6	68.4
90.00	16.3	8.9	42.9
112.50	27.5	13.7	68.7
135.00	30.8	12.4	67.9
157.50	13.2	5.0	28.3
180.00	16.1	7.4	38.4
202.50	16.9	7.2	38.5
225.00	21.8	9.5	50.1
247.50	16.6	6.8	36.9
270.00	19.1	7.2	40.6
292.50	19.9	6.0	38.0
315.00	20.6	6.0	38.5
337.50	24.2	8.0	48.1

LOCATION 28

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	31.1	11.5	65.5
22.50	28.2	13.6	69.0
45.00	12.1	6.6	31.9
67.50	11.2	5.9	28.9
90.00	15.1	8.2	39.7
112.50	27.1	10.3	58.0
135.00	25.2	8.6	50.9
157.50	17.1	6.6	37.0
180.00	13.0	5.3	28.9
202.50	14.2	6.9	34.8
225.00	14.6	6.0	32.5
247.50	15.6	6.9	36.2
270.00	15.8	6.4	35.1
292.50	12.4	4.8	26.8
315.00	17.5	7.7	40.7
337.50	27.3	9.1	54.5

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 29

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	21.0	9.8	50.5
22.50	17.7	8.3	42.7
45.00	17.2	10.7	49.2
67.50	24.6	14.6	68.5
90.00	38.1	17.4	90.2
112.50	34.7	18.0	88.8
135.00	30.5	12.4	67.6
157.50	15.8	7.7	39.0
180.00	13.4	5.2	29.0
202.50	16.3	6.3	35.3
225.00	22.5	9.1	49.8
247.50	24.0	9.1	51.3
270.00	25.7	11.5	60.2
292.50	38.4	11.6	73.2
315.00	28.8	10.5	60.3
337.50	28.4	11.4	62.4

LOCATION 30

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	25.3	11.6	60.0
22.50	20.4	7.5	43.0
45.00	33.8	12.8	72.1
67.50	35.6	13.3	75.4
90.00	32.5	11.2	66.2
112.50	27.5	13.2	67.1
135.00	15.2	6.0	33.3
157.50	17.7	7.4	40.0
180.00	17.1	7.4	39.5
202.50	25.1	10.7	57.1
225.00	24.9	12.7	62.9
247.50	28.1	13.8	69.5
270.00	29.0	14.0	71.0
292.50	20.7	9.1	48.0
315.00	20.0	8.6	45.8
337.50	22.7	9.8	52.1

LOCATION 31

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	16.2	6.9	36.9
22.50	18.5	7.9	42.2
45.00	14.7	8.1	39.0
67.50	11.2	6.5	30.8
90.00	13.3	6.7	33.4
112.50	14.3	6.5	33.8
135.00	13.6	4.6	27.3
157.50	10.3	3.4	20.6
180.00	10.4	3.1	19.9
202.50	15.4	5.2	30.9
225.00	16.3	5.3	32.2
247.50	14.5	5.8	31.8
270.00	18.8	6.9	39.5
292.50	15.3	6.0	33.4
315.00	16.4	7.2	38.1
337.50	17.5	7.8	41.0

LOCATION 32

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	15.6	5.9	33.4
22.50	18.8	8.0	42.7
45.00	24.8	9.5	53.2
67.50	25.6	10.1	55.8
90.00	37.7	14.6	81.6
112.50	26.8	12.2	63.4
135.00	20.9	8.1	45.1
157.50	20.0	8.8	46.4
180.00	17.4	7.1	38.8
202.50	18.8	6.5	38.3
225.00	21.7	9.2	49.2
247.50	23.7	10.6	55.6
270.00	23.4	9.1	50.7
292.50	20.7	7.9	44.5
315.00	16.7	6.3	35.7
337.50	21.3	7.9	44.9

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 33

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	18.7	8.6	44.6
22.50	20.0	9.8	49.4
45.00	21.5	9.3	49.3
67.50	21.8	9.9	51.4
90.00	22.2	9.9	51.9
112.50	21.4	11.5	56.0
135.00	27.6	12.4	64.9
157.50	36.7	13.8	78.2
180.00	45.0	14.3	87.9
202.50	57.8	17.1	109.1
225.00	33.7	11.1	67.0
247.50	19.2	8.4	44.4
270.00	23.1	10.1	53.4
292.50	20.1	9.2	47.7
315.00	29.6	13.4	69.9
337.50	26.0	12.8	64.5

LOCATION 34

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	18.1	10.3	49.1
22.50	31.6	16.1	80.1
45.00	28.7	13.1	67.9
67.50	33.5	11.8	68.9
90.00	27.7	13.6	68.6
112.50	18.4	9.9	48.1
135.00	22.8	10.9	55.5
157.50	21.1	10.5	52.8
180.00	16.1	7.4	38.3
202.50	16.7	7.2	38.4
225.00	12.9	5.1	28.2
247.50	12.2	5.1	27.7
270.00	13.4	5.9	31.2
292.50	12.8	5.2	28.5
315.00	12.9	5.7	30.0
337.50	15.3	9.2	42.9

LOCATION 35

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	49.3	17.0	100.3
22.50	22.9	13.3	62.6
45.00	19.0	11.1	52.3
67.50	15.9	9.6	44.6
90.00	22.2	13.4	62.4
112.50	35.6	14.4	78.7
135.00	42.8	16.6	92.7
157.50	45.8	15.6	92.6
180.00	35.2	14.9	79.9
202.50	35.7	14.0	77.6
225.00	40.3	16.5	90.0
247.50	20.1	9.8	49.5
270.00	14.1	6.0	32.1
292.50	26.8	10.6	58.6
315.00	52.8	16.2	101.5
337.50	48.1	13.6	88.8

LOCATION 36

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	33.1	12.3	70.0
22.50	37.8	10.3	68.7
45.00	36.1	10.1	66.4
67.50	28.2	12.2	64.8
90.00	40.6	16.4	89.6
112.50	26.9	11.8	62.2
135.00	19.9	7.0	40.8
157.50	21.4	9.0	48.4
180.00	21.0	9.0	47.9
202.50	23.6	11.2	57.3
225.00	19.6	9.4	47.7
247.50	19.0	7.9	42.9
270.00	19.4	8.9	46.1
292.50	26.0	10.4	57.3
315.00	20.2	7.6	43.0
337.50	23.3	10.0	53.3

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

LOCATION 37

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	20.7	9.7	49.8
22.50	20.1	9.8	49.4
45.00	14.7	7.4	37.0
67.50	19.8	9.7	48.9
90.00	23.6	11.3	57.7
112.50	30.9	13.1	70.1
135.00	23.6	10.2	54.3
157.50	27.2	14.3	70.0
180.00	27.4	13.6	68.2
202.50	31.2	17.7	84.3
225.00	18.7	9.5	47.3
247.50	31.4	13.0	70.3
270.00	30.6	14.2	73.1
292.50	30.0	14.8	74.3
315.00	20.5	9.8	50.0
337.50	24.5	11.9	60.3

LOCATION 38

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	22.4	12.3	59.3
22.50	20.7	12.2	57.2
45.00	19.0	10.5	50.4
67.50	21.7	10.9	54.4
90.00	24.8	11.5	59.2
112.50	27.5	12.5	65.0
135.00	22.8	9.5	51.3
157.50	16.1	6.2	34.7
180.00	15.1	6.1	33.4
202.50	18.9	8.9	45.5
225.00	17.8	7.7	40.8
247.50	19.2	8.9	45.8
270.00	20.4	9.9	50.1
292.50	17.0	7.2	38.5
315.00	24.3	13.9	66.1
337.50	27.8	12.0	63.8

LOCATION 39

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	17.3	7.4	39.5
22.50	18.5	8.8	45.1
45.00	18.6	9.3	46.5
67.50	28.9	11.1	62.1
90.00	34.2	11.8	69.6
112.50	32.6	12.1	68.8
135.00	23.4	9.9	53.2
157.50	16.6	6.7	36.8
180.00	29.4	14.9	74.2
202.50	38.9	14.7	82.9
225.00	28.5	10.2	59.3
247.50	34.0	13.8	75.5
270.00	35.2	15.0	80.2
292.50	33.9	14.2	76.5
315.00	25.3	9.6	54.2
337.50	25.1	10.9	57.9

LOCATION 40

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	25.0	11.3	58.9
22.50	22.8	10.6	54.6
45.00	26.8	15.3	72.9
67.50	38.6	17.3	90.5
90.00	53.6	22.2	120.2
112.50	21.6	13.4	61.8
135.00	18.9	6.9	39.7
157.50	24.2	9.1	51.6
180.00	21.2	8.7	47.3
202.50	18.8	7.8	42.1
225.00	35.4	14.7	79.5
247.50	64.9	16.0	113.0
270.00	61.4	12.1	97.8
292.50	56.6	12.0	92.6
315.00	47.0	11.6	81.8
337.50	38.7	13.2	78.4

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration B - Preliminary version, Rubin Dev, w/ city

* * GREATEST VALUES * *

U/UR (PERCENT)					URMS/UR (PERCENT)					U+3*URMS /UR (PERCENT)				
LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS
		----						---						------
1	67.5	65.6	14.3	108.4	40	90.0	53.6	22.2	120.2	40	90.0	53.6	22.2	120.2
40	247.5	64.9	16.0	113.0	1	45.0	54.6	19.4	112.7	40	247.5	64.9	16.0	113.0
40	270.0	61.4	12.1	97.8	13	45.0	30.1	19.0	87.1	1	45.0	54.6	19.4	112.7
1	90.0	61.1	12.4	98.3	29	112.5	34.7	18.0	88.8	33	202.5	57.8	17.1	109.1
8	112.5	58.5	11.3	92.4	11	45.0	39.5	17.9	93.1	1	67.5	65.6	14.3	108.4
33	202.5	57.8	17.1	109.1	10	45.0	30.3	17.8	83.7	14	292.5	53.1	16.4	102.3
40	292.5	56.6	12.0	92.6	37	202.5	31.2	17.7	84.3	35	315.0	52.8	16.2	101.5
1	112.5	56.3	11.5	90.8	29	90.0	38.1	17.4	90.2	35	0.0	49.3	17.0	100.3
1	45.0	54.6	19.4	112.7	40	67.5	38.6	17.3	90.5	1	90.0	61.1	12.4	98.3
40	90.0	53.6	22.2	120.2	33	202.5	57.8	17.1	109.1	40	270.0	61.4	12.1	97.8
14	292.5	53.1	16.4	102.3	35	0.0	49.3	17.0	100.3	6	22.5	51.3	15.2	97.0
35	315.0	52.8	16.2	101.5	11	22.5	39.2	17.0	90.1	6	45.0	46.0	16.5	95.4
6	22.5	51.3	15.2	97.0	35	135.0	42.8	16.6	92.7	24	67.5	45.9	16.2	94.5
25	67.5	51.0	12.9	89.6	35	225.0	40.3	16.5	90.0	8	135.0	44.5	16.3	93.3
6	0.0	50.3	13.5	90.9	6	45.0	46.0	16.5	95.4	11	45.0	39.5	17.9	93.1

TYPICAL VALUES FOR AN OPEN-COUNTRY SITE :

U/UR = 45-50 PERCENT
URMS/UR = 10-12 PERCENT
U+3*URMS/UR = 75-85 PERCENT

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration C - Existing site w/ corrected garage

LOCATION 1

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	33.8	8.8	60.3
22.50	23.7	9.5	52.2
45.00	10.7	7.4	33.0
67.50	12.6	8.0	36.6
90.00	20.6	9.1	48.0
112.50	30.7	11.4	64.9
135.00	29.9	11.1	63.2
157.50	21.5	9.5	50.1
180.00	12.8	5.8	30.3
202.50	20.5	10.2	51.2
225.00	27.3	12.7	65.4
247.50	16.4	8.2	41.0
270.00	16.6	6.9	37.4
292.50	24.8	8.8	51.1
315.00	37.7	8.6	63.6
337.50	36.8	8.7	63.0

LOCATION 24

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	30.8	10.0	60.7
22.50	19.5	7.8	43.0
45.00	8.3	6.2	26.8
67.50	11.2	6.6	31.2
90.00	15.3	8.0	39.4
112.50	25.8	10.0	55.8
135.00	34.8	9.9	64.5
157.50	27.9	9.9	57.5
180.00	14.3	7.2	36.0
202.50	21.5	10.3	52.3
225.00	27.0	12.6	64.9
247.50	13.1	6.5	32.5
270.00	20.6	7.2	42.3
292.50	28.8	7.7	52.1
315.00	35.8	9.4	64.2
337.50	34.7	9.6	63.6

LOCATION 25

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	12.8	5.1	27.9
22.50	13.0	6.2	31.7
45.00	16.5	8.9	43.3
67.50	20.6	8.5	46.2
90.00	22.7	10.6	54.5
112.50	30.7	12.3	67.6
135.00	34.3	11.1	67.5
157.50	15.6	7.7	38.6
180.00	13.9	6.5	33.5
202.50	15.4	7.4	37.7
225.00	17.5	7.9	41.3
247.50	21.1	9.5	49.6
270.00	29.6	10.2	60.1
292.50	36.3	10.9	69.0
315.00	29.2	8.8	55.6
337.50	19.6	8.5	45.1

LOCATION 26

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	26.7	12.0	62.5
22.50	31.2	12.1	67.4
45.00	15.5	9.8	44.9
67.50	28.0	10.4	59.2
90.00	27.2	11.1	60.5
112.50	40.1	12.6	78.0
135.00	28.9	12.1	65.1
157.50	12.8	5.6	29.5
180.00	17.4	9.9	47.0
202.50	16.6	8.4	41.7
225.00	19.4	9.9	49.1
247.50	17.1	7.5	39.7
270.00	23.8	7.5	46.2
292.50	25.4	8.6	51.1
315.00	25.4	6.9	46.2
337.50	20.9	6.6	40.6

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration C - Existing site w/ corrected garage

* * GREATEST VALUES * *

U/UR (PERCENT)					URMS/UR (PERCENT)					U+3*URMS /UR (PERCENT)				
LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS
26	112.5	40.1	12.6	78.0	1	225.0	27.3	12.7	65.4	26	112.5	40.1	12.6	78.0
1	315.0	37.7	8.6	63.6	26	112.5	40.1	12.6	78.0	25	292.5	36.3	10.9	69.0
1	337.5	36.8	8.7	63.0	24	225.0	27.0	12.6	64.9	25	112.5	30.7	12.3	67.6
25	292.5	36.3	10.9	69.0	25	112.5	30.7	12.3	67.6	25	135.0	34.3	11.1	67.5
24	315.0	35.8	9.4	64.2	26	135.0	28.9	12.1	65.1	26	22.5	31.2	12.1	67.4
24	135.0	34.8	9.9	64.5	26	22.5	31.2	12.1	67.4	1	225.0	27.3	12.7	65.4
24	337.5	34.7	9.6	63.6	26	0.0	26.7	12.0	62.5	26	135.0	28.9	12.1	65.1
25	135.0	34.3	11.1	67.5	1	112.5	30.7	11.4	64.9	24	225.0	27.0	12.6	64.9
1	0.0	33.8	8.8	60.3	26	90.0	27.2	11.1	60.5	1	112.5	30.7	11.4	64.9
26	22.5	31.2	12.1	67.4	1	135.0	29.9	11.1	63.2	24	135.0	34.8	9.9	64.5
24	0.0	30.8	10.0	60.7	25	135.0	34.3	11.1	67.5	24	315.0	35.8	9.4	64.2
25	112.5	30.7	12.3	67.6	25	292.5	36.3	10.9	69.0	1	315.0	37.7	8.6	63.6
1	112.5	30.7	11.4	64.9	25	90.0	22.7	10.6	54.5	24	337.5	34.7	9.6	63.6
1	135.0	29.9	11.1	63.2	26	67.5	28.0	10.4	59.2	1	135.0	29.9	11.1	63.2
25	270.0	29.6	10.2	60.1	24	202.5	21.5	10.3	52.3	1	337.5	36.8	8.7	63.0

TYPICAL VALUES FOR AN OPEN-COUNTRY SITE :

U/UR = 45-50 PERCENT
URMS/UR = 10-12 PERCENT
U+3*URMS/UR = 75-85 PERCENT

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration D - Amelioration change #1

LOCATION 1

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	19.4	8.6	45.3
22.50	20.1	10.6	51.8
45.00	31.4	13.3	71.4
67.50	30.8	10.9	63.5
90.00	64.0	14.7	108.1
112.50	57.8	12.9	96.6
135.00	24.2	12.5	61.6
157.50	11.9	5.9	29.7
180.00	9.5	4.3	22.5
202.50	10.9	5.6	27.6
225.00	22.2	10.7	54.4
247.50	25.9	9.7	54.9
270.00	33.9	9.2	61.4
292.50	35.8	9.9	65.4
315.00	37.2	9.0	64.3
337.50	31.6	10.5	63.0

LOCATION 6

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	27.0	15.8	74.4
22.50	53.1	16.5	102.5
45.00	50.5	17.8	104.0
67.50	34.7	16.4	83.9
90.00	13.0	9.3	40.9
112.50	30.4	18.6	86.2
135.00	50.1	14.6	93.9
157.50	27.5	12.2	64.0
180.00	16.8	9.3	44.7
202.50	16.4	9.6	45.2
225.00	16.2	8.7	42.4
247.50	19.1	10.1	49.5
270.00	19.7	11.2	53.5
292.50	13.5	6.8	33.9
315.00	11.6	5.2	27.2
337.50	15.6	8.5	41.2

LOCATION 8

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	32.6	12.4	69.8
22.50	17.4	9.7	46.5
45.00	33.2	15.9	80.9
67.50	45.1	14.5	88.4
90.00	53.3	14.7	97.4
112.50	62.1	13.5	102.6
135.00	41.8	15.0	86.8
157.50	21.2	10.4	52.4
180.00	12.6	5.9	30.4
202.50	14.4	6.9	35.2
225.00	22.3	10.1	52.5
247.50	30.1	13.8	71.6
270.00	42.4	13.1	81.6
292.50	36.6	10.5	68.1
315.00	31.2	12.1	67.4
337.50	38.6	13.4	78.9

LOCATION 24

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	25.8	9.3	53.7
22.50	16.3	7.9	39.9
45.00	33.9	17.3	85.7
67.50	46.6	16.6	96.3
90.00	46.3	13.8	87.7
112.50	44.7	11.1	77.9
135.00	23.4	11.3	57.4
157.50	18.9	8.7	45.0
180.00	13.3	7.0	34.4
202.50	21.9	11.8	57.3
225.00	33.7	14.3	76.5
247.50	22.9	13.3	62.7
270.00	21.1	10.2	51.8
292.50	23.8	11.4	57.9
315.00	28.5	9.7	57.6
337.50	29.4	8.2	53.9

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration 0 - Amelioration change #1

LOCATION 25				LOCATION 26			
WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)	WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	23.3	13.8	64.7	0.00	34.6	10.9	67.3
22.50	27.9	13.0	67.0	22.50	31.7	12.1	68.1
45.00	43.9	12.2	80.4	45.00	32.1	15.7	79.2
67.50	46.9	13.8	88.2	67.50	36.4	15.8	83.9
90.00	27.4	14.0	69.4	90.00	20.2	14.2	62.9
112.50	17.8	9.4	46.1	112.50	22.9	15.8	70.4
135.00	24.8	10.7	56.8	135.00	35.3	13.8	76.8
157.50	14.3	6.0	32.2	157.50	11.7	5.5	28.2
180.00	15.1	7.9	38.9	180.00	18.1	10.7	50.3
202.50	22.8	10.5	54.3	202.50	18.2	10.0	48.2
225.00	28.6	11.1	62.0	225.00	20.7	10.1	51.0
247.50	20.6	9.8	50.0	247.50	15.0	6.8	35.5
270.00	18.6	8.7	44.7	270.00	22.1	8.1	46.3
292.50	22.4	10.5	54.1	292.50	25.9	7.9	49.5
315.00	16.6	8.4	41.8	315.00	25.1	6.8	45.7
337.50	19.6	11.0	52.6	337.50	24.9	8.4	49.9

LOCATION 41				LOCATION 42			
WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)	WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	23.4	11.2	56.9	0.00	15.9	7.2	37.6
22.50	17.6	9.5	46.0	22.50	11.2	5.5	27.6
45.00	53.2	16.5	102.7	45.00	8.0	7.7	31.2
67.50	55.3	14.6	99.2	67.50	5.9	4.9	20.7
90.00	52.3	14.0	94.1	90.00	12.2	8.9	38.8
112.50	36.5	13.5	76.9	112.50	22.6	11.6	57.5
135.00	8.6	3.0	17.5	135.00	34.7	15.0	79.5
157.50	7.9	2.9	16.6	157.50	16.3	8.3	41.2
180.00	7.0	2.7	15.2	180.00	11.2	5.2	26.7
202.50	6.5	2.5	13.9	202.50	13.6	7.0	34.6
225.00	6.2	1.9	11.8	225.00	21.7	10.9	54.6
247.50	8.9	5.0	23.8	247.50	25.3	11.7	60.5
270.00	11.8	6.7	32.1	270.00	37.3	13.8	78.7
292.50	23.8	13.6	64.7	292.50	32.5	9.3	60.6
315.00	41.2	12.4	78.5	315.00	33.3	9.6	62.1
337.50	42.5	11.8	77.8	337.50	30.7	9.6	59.6

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration D - Amelioration change #1

* * GREATEST VALUES * *

U/UR (PERCENT)					URMS/UR (PERCENT)					U+3*URMS /UR (PERCENT)				
LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS
1	90.0	64.0	14.7	108.1	6	112.5	30.4	18.6	86.2	1	90.0	64.0	14.7	108.1
8	112.5	62.1	13.5	102.6	6	45.0	50.5	17.8	104.0	6	45.0	50.5	17.8	104.0
1	112.5	57.8	12.9	96.6	24	45.0	33.9	17.3	85.7	41	45.0	53.2	16.5	102.7
41	67.5	55.3	14.6	99.2	24	67.5	46.6	16.6	96.3	8	112.5	62.1	13.5	102.6
8	90.0	53.3	14.7	97.4	41	45.0	53.2	16.5	102.7	6	22.5	53.1	16.5	102.5
41	45.0	53.2	16.5	102.7	6	22.5	53.1	16.5	102.5	41	67.5	55.3	14.6	99.2
6	22.5	53.1	16.5	102.5	6	67.5	34.7	16.4	83.9	8	90.0	53.3	14.7	97.4
41	90.0	52.3	14.0	94.1	8	45.0	33.2	15.9	80.9	1	112.5	57.8	12.9	96.6
6	45.0	50.5	17.8	104.0	26	67.5	36.4	15.8	83.9	24	67.5	46.6	16.6	96.3
6	135.0	50.1	14.6	93.9	26	112.5	22.9	15.8	70.4	41	90.0	52.3	14.0	94.1
25	67.5	46.9	13.8	88.2	6	0.0	27.0	15.8	74.4	6	135.0	50.1	14.6	93.9
24	67.5	46.6	16.6	96.3	26	45.0	32.1	15.7	79.2	8	67.5	45.1	14.5	88.4
24	90.0	46.3	13.8	87.7	8	135.0	41.8	15.0	86.8	25	67.5	46.9	13.8	88.2
8	67.5	45.1	14.5	88.4	42	135.0	34.7	15.0	79.5	24	90.0	46.3	13.8	87.7
24	112.5	44.7	11.1	77.9	8	90.0	53.3	14.7	97.4	8	135.0	41.8	15.0	86.8

TYPICAL VALUES FOR AN OPEN-COUNTRY SITE :

U/UR = 45-50 PERCENT
URMS/UR = 10-12 PERCENT
U+3*URMS/UR = 75-85 PERCENT

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration E - Amelioration change #2

LOCATION 1

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	20.4	10.2	50.9
22.50	17.8	10.6	49.5
45.00	46.9	18.1	101.3
67.50	55.2	14.1	97.6
90.00	51.9	12.0	88.0
112.50	36.1	12.3	73.1
135.00	20.9	11.6	55.6
157.50	11.1	7.7	34.0
180.00	6.4	3.6	17.3
202.50	8.5	5.4	24.8
225.00	13.1	8.8	39.7
247.50	16.7	8.7	42.7
270.00	24.0	8.9	50.7
292.50	26.3	8.1	50.7
315.00	31.7	9.6	60.7
337.50	28.2	11.1	61.4

LOCATION 8

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	15.6	8.3	40.5
22.50	13.3	8.2	37.9
45.00	29.6	14.5	73.8
67.50	38.7	15.4	84.9
90.00	52.1	14.0	94.2
112.50	65.8	13.9	107.5
135.00	41.5	15.6	88.2
157.50	20.1	10.8	52.5
180.00	11.2	7.6	34.0
202.50	14.3	8.7	40.5
225.00	18.8	9.7	47.9
247.50	25.3	13.3	65.3
270.00	28.1	9.9	57.7
292.50	23.3	8.2	47.8
315.00	17.9	7.6	40.7
337.50	23.7	8.3	48.6

LOCATION 43

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	39.5	12.7	77.7
22.50	44.1	14.1	86.5
45.00	57.1	19.4	115.3
67.50	42.0	20.9	104.8
90.00	28.1	14.7	72.1
112.50	29.8	14.0	71.8
135.00	36.3	15.6	83.1
157.50	16.9	8.9	43.7
180.00	8.4	5.6	25.2
202.50	26.9	12.1	63.3
225.00	20.9	11.0	53.9
247.50	38.0	13.0	77.0
270.00	41.1	14.9	85.9
292.50	34.2	14.8	78.7
315.00	40.7	14.2	83.4
337.50	37.3	18.2	91.8

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration E - Amelioration change #2

* * GREATEST VALUES * *

U/UR (PERCENT)					URMS/UR (PERCENT)					U+3*URMS /UR (PERCENT)				
LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS
8	112.5	65.8	13.9	107.5	43	67.5	42.0	20.9	104.8	43	45.0	57.1	19.4	115.3
43	45.0	57.1	19.4	115.3	43	45.0	57.1	19.4	115.3	8	112.5	65.8	13.9	107.5
1	67.5	55.2	14.1	97.6	43	337.5	37.3	18.2	91.8	43	67.5	42.0	20.9	104.8
8	90.0	52.1	14.0	94.2	1	45.0	46.9	18.1	101.3	1	45.0	46.9	18.1	101.3
1	90.0	51.9	12.0	88.0	43	135.0	36.3	15.6	83.1	1	67.5	55.2	14.1	97.6
1	45.0	46.9	18.1	101.3	8	135.0	41.5	15.6	88.2	8	90.0	52.1	14.0	94.2
43	22.5	44.1	14.1	86.5	8	67.5	38.7	15.4	84.9	43	337.5	37.3	18.2	91.8
43	67.5	42.0	20.9	104.8	43	270.0	41.1	14.9	85.9	8	135.0	41.5	15.6	88.2
8	135.0	41.5	15.6	88.2	43	292.5	34.2	14.8	78.7	1	90.0	51.9	12.0	88.0
43	270.0	41.1	14.9	85.9	43	90.0	28.1	14.7	72.1	43	22.5	44.1	14.1	86.5
43	315.0	40.7	14.2	83.4	8	45.0	29.6	14.5	73.0	43	270.0	41.1	14.9	85.9
43	0.0	39.5	12.7	77.7	43	315.0	40.7	14.2	83.4	8	67.5	38.7	15.4	84.9
8	67.5	38.7	15.4	84.9	43	22.5	44.1	14.1	86.5	43	315.0	40.7	14.2	83.4
43	247.5	38.0	13.0	77.0	1	67.5	55.2	14.1	97.6	43	135.0	36.3	15.6	83.1
43	337.5	37.3	18.2	91.8	43	112.5	29.8	14.0	71.8	43	292.5	34.2	14.8	78.7

TYPICAL VALUES FOR AN OPEN-COUNTRY SITE :

U/UR = 45-50 PERCENT
URMS/UR = 10-12 PERCENT
U+3*URMS/UR = 75-85 PERCENT

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration F - Amelioration change #3

LOCATION 8

WIND AZIMUTH	U/UR (PERCENT)	URMS/UR (PERCENT)	U+3*URMS/UR (PERCENT)
0.00	13.7	6.8	34.1
22.50	10.5	6.0	28.4
45.00	18.9	9.7	47.9
67.50	27.0	13.2	66.6
90.00	17.5	10.7	49.5
112.50	17.6	7.9	41.4
135.00	17.3	8.8	43.6
157.50	8.9	5.1	24.1
180.00	7.1	4.4	20.2
202.50	11.5	7.5	34.0
225.00	17.0	9.4	45.3
247.50	25.3	13.5	65.7
270.00	22.9	11.0	56.0
292.50	14.7	8.0	38.7
315.00	12.2	6.5	31.8
337.50	19.2	8.9	45.7

TABLE 1

NON-DIMENSIONAL PEDESTRIAN WIND VELOCITIES AND PEAK GUSTS

Rubin Development, Boston

Configuration F - Amelioration change #3

* * GREATEST VALUES * *

U/UR (PERCENT)					URMS/UR (PERCENT)					U+3*URMS /UR (PERCENT)				
LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS	LOC	AZ	MEAN	RMS	M+3RMS
8	67.5	27.0	13.2	66.6	8	247.5	25.3	13.5	65.7	8	67.5	27.0	13.2	66.6
8	247.5	25.3	13.5	65.7	8	67.5	27.0	13.2	66.6	8	247.5	25.3	13.5	65.7
8	270.0	22.9	11.0	56.0	8	270.0	22.9	11.0	56.0	8	270.0	22.9	11.0	56.0
8	337.5	19.2	8.9	45.7	8	90.0	17.5	10.7	49.5	8	90.0	17.5	10.7	49.5
8	45.0	18.9	9.7	47.9	8	45.0	18.9	9.7	47.9	8	45.0	18.9	9.7	47.9
8	112.5	17.6	7.9	41.4	8	225.0	17.0	9.4	45.3	8	337.5	19.2	8.9	45.7
8	90.0	17.5	10.7	49.5	8	337.5	19.2	8.9	45.7	8	225.0	17.0	9.4	45.3
8	135.0	17.3	8.8	43.6	8	135.0	17.3	8.8	43.6	8	135.0	17.3	8.8	43.6
8	225.0	17.0	9.4	45.3	8	292.5	14.7	8.0	38.7	8	112.5	17.6	7.9	41.4
8	292.5	14.7	8.0	38.7	8	112.5	17.6	7.9	41.4	8	292.5	14.7	8.0	38.7
8	0.0	13.7	6.8	34.1	8	202.5	11.5	7.5	34.0	8	0.0	13.7	6.8	34.1
8	315.0	12.2	6.5	31.8	8	0.0	13.7	6.8	34.1	8	202.5	11.5	7.5	34.0
8	202.5	11.5	7.5	34.0	8	315.0	12.2	6.5	31.8	8	315.0	12.2	6.5	31.8
8	22.5	10.5	6.0	28.4	8	22.5	10.5	6.0	28.4	8	22.5	10.5	6.0	28.4
8	157.5	8.9	5.1	24.1	8	157.5	8.9	5.1	24.1	8	157.5	8.9	5.1	24.1

TYPICAL VALUES FOR AN OPEN-COUNTRY SITE :

U/UR = 45-50 PERCENT
URMS/UR = 10-12 PERCENT
U+3*URMS/UR = 75-85 PERCENT

TABLE 2

Data Configurations

Configuration A :

Geometry - Existing Rubin Development site, with surrounding city model.

Velocities - Pedestrian winds measured for 16 wind directions, in 22.5-degree increments from 0, for locations 1 - 40 (Figure 5). Flow characterized visually as being in one of four wind speed categories for eight principal wind directions in each of sixteen zones.

Configuration B :

Geometry - Rubin Development in place, with surrounding city model.

Velocities - Pedestrian winds measured for 16 wind directions, in 22.5-degree increments from 0, for locations 1 - 40 (Figure 5). Flow characterized visually as being in one of four wind speed categories for eight principal wind directions in each of sixteen zones.

Configuration C :

Geometry - Existing Rubin Development site, with surrounding city model. Nearby garage modified to include undercut at JFK Expressway end, trees added in Curly Park, and 75' building added on Blackstone street.

Velocities - Pedestrian winds measured for 16 wind directions, in 22.5-degree increments from 0, for locations 1 & 24-26 (Figure 5).

TABLE 2 (Continued)

Configuration D :

Geometry - Rubin Development in place, with amelioration #1 changes. Nearby garage modified to include undercut at JFK Expressway end, trees added in Curly Park, and 75' building added on Blackstone street.

Velocities - Pedestrian winds measured for 16 wind directions, in 22.5-degree increments from 0, for locations 1, 6, 8, 24-26, & 41-42 (see Figure 5).

Configuration E :

Geometry - Rubin Development in place, with amelioration #2 changes. Nearby garage modified to include undercut at JFK Expressway end, trees added in Curly Park, and 75' building added on Blackstone street.

Velocities - Pedestrian winds measured for 16 wind directions, in 22.5-degree increments from 0, for locations 1, 8, and 43 (see Figure 5).

Configuration F :

Geometry - Rubin Development in place, with amelioration #3 changes. Nearby garage modified to include undercut at JFK Expressway end, trees added in Curly Park, and 75' building added on Blackstone street. Same as Configuration E but with 6' high planters near point 8.

Velocities - Pedestrian winds measured for 16 wind directions, in 22.5-degree increments from 0, for location 8 (see Figure 5).

TABLE 3

SUMMARY OF WIND EFFECTS ON PEOPLE

Description	Beaufort Number	Speed (mph)	Effects
Calm, light air	0,1	0- 3	Calm, no noticeable wind
Light breeze	2	4- 7	Wind felt on face
Gentle breeze	3	8-12	Wind extends light flag Hair is disturbed Clothing flaps
Moderate breeze	4	13-18	Raises dust, dry soil and loose paper Hair disarranged
Fresh breeze	5	19-24	Force of wind felt on body Drifting snow becomes airborne Limit of agreeable wind on land
Strong breeze	6	25-31	Umbrellas used with difficulty Hair blown straight Difficult to walk steadily Wind noise on ears unpleasant Windborne snow above head height (blizzard)
Near gale	7	32-38	Inconvenience felt when walking
Gale	8	39-46	Generally impedes progress Great difficulty with balance in gusts
Strong gale	9	47-54	People blown over by gusts

NOTE: Table from Reference 4.

TABLE 4

RESULTS OF FLOW VISUALIZATION STUDY

Number of Wind Directions with Specified Wind Speed

Zone Number	Configuration	Wind Speed High	Moderate	Low	Stagnant
1	A (Existing)		2	4	2
	B (Preliminary)		3	2	3
2	A		4	4	
	B	1	3	4	
3	A		1	6	1
	B		1	5	2
4	A			7	1
	B		2	5	1
5	A			7	1
	B			7	1
6	A		2	5	1
	B		1	6	1
7	A			6	2
	B			6	2
8	A		2	4	2
	B		2	4	2
9	A	1	2	5	
	B	1	2	5	
10	A		4	3	1
	B		3	4	1
11	A		2	4	2
	B		2	4	2
12	A		7	1	
	B		7	1	
13	A		1	7	
	B		1	7	
14	A	5	3		
	B	5	3		
15	A	4	3	1	
	B	4	3	1	
16	A	1	4	3	
	B	1	4	3	

TABLE 5

EFFECTIVE GUST (MEAN + 1.5 RMS) VELOCITIES (mph) EXCEEDED ONE PERCENT OF THE TIME

Location	A	B
1	20	-35-
2	20	22
3	20	29
4	23	27
5	20	25
6	23	30
7	19	20
8	22	-32-
9	24	26
10	20	27
11	25	28
12	19	21
13	20	24
14	-35-	-35-
15	26	26
16	20	20
17	28	26
18	22	20
19	22	20
20	20	19
21	22	22
22	15	17
23	24	24
24	25	28
25	22	27
26	23	24
27	23	22
28	20	20
29	25	27
30	27	25
31	15	15
32	22	23
33	30	30
34	23	22
35	-33-	-33-
36	27	25
37	29	27
38	22	20
39	29	29
40	-41-	-40-

TABLE 5

EFFECTIVE GUST (MEAN + 1.5 RMS) VELOCITIES (mph) EXCEEDED ONE PERCENT OF THE TIME

Location	C	D	E	F
1	23	-33-	31	
2				
3				
4				
5				
6		30		
7				
8		31	-32-	20
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	23	29		
25	25	26		
26	23	25		
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41		-33-		
42		27		
43			-35-	

TABLE 6

MEAN VELOCITIES (mph) EXCEEDED ONE PERCENT OF THE TIME

Location	A	B
1	14	26
2	12	15
3	13	20
4	14	19
5	14	16
6	15	21
7	11	12
8	12	23
9	15	16
10	13	18
11	18	18
12	12	14
13	12	14
14	24	24
15	18	18
16	14	14
17	20	18
18	13	12
19	15	12
20	12	11
21	13	12
22	9	9
23	15	15
24	17	18
25	15	19
26	16	17
27	15	14
28	13	12
29	16	18
30	17	15
31	9	9
32	14	14
33	21	21
34	14	13
35	23	22
36	18	17
37	17	15
38	13	12
39	18	18
40	30	30

TABLE 6

MEAN VELOCITIES (mph) EXCEEDED ONE PERCENT OF THE TIME

Location	C	D	E	F
1	16	24	21	
2				
3				
4				
5				
6		19		
7				
8		24	24	21
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24	15	19		
25	17	18		
26	15	15		
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41		23		
42		18		
43			22	

APPENDIX A

WIND DEFINITION

WIND DEFINITION

Definition of the wind climate in Boston is complicated by the complex coastal geometry which can cause atmospheric stability effects to be significant for a wide range of wind speeds. Two types of stability can affect the winds: 1) stably stratified winds where the ground or water surface is cooler than the overlying air mass, and 2) unstably stratified winds where the ground or water surface is warmer than the overlying air mass. Stability effects can effectively change the distribution of mean velocity and turbulence intensity with height above the surface. the coastal site can also influence wind climatology through temperature differences between land and water. These temperature differences can induce winds locally near the coast which are not closely associated with larger (synoptic or meso) scale atmospheric motions driving the general atmospheric circulations and weather patterns. All of these thermally induced effects are most influential for the lower speed winds which are significant for pedestrian comfort applications. These effects become insignificant for the extreme wind events which the building frame and cladding are designed to resist because turbulent mixing at high wind speeds destroys the thermal gradients within the atmospheric boundary layer.

Location of National Weather Service anemometers at Logan International Airport provides a good source of wind data which is in an open area away from significant influence of buildings but close enough to the City of Boston to have winds representative of the City. The airport has three basic sources of wind data: 1) hourly data from an anemometer at 22 feet above ground which provides representative data for pedestrian level winds, 2) fastest-mile data from an anemometer which varied in elevation from 22 feet to 62 feet in elevation which provides low probability event data not present in the hourly data at 22 feet, and 3) pilot balloon wind profile data which provides information primarily on winds at the top of the atmospheric boundary layer.

An analysis of the surface winds was made to determine the consistency of the hourly and fastest-mile wind data and to determine its applicability for use for pedestrian wind analysis and structural loading. Figure A.1 shows the results of that analysis. The data points are the cumulative distribution of winds by direction (open circles) and individual fastest-mile wind events (solid circles). The hourly data were translated to a gradient height of 900 feet with a 0.16 power law. Thus, both sets of data were brought to a common time average and elevation. In actuality, the hourly data are not true hourly averages, but are one-minute averages obtained once an hour, on the hour. The best estimate of the hourly mean from those samples is the sample value although some samples will obviously be too high or low. A method to correct these data to something approximating true hourly means is in research stages by the authors, but was not incorporated here due to the stability effects noted in the data.

The fastest-mile events shown in Figure A.1 were established by obtaining the largest fastest-mile wind events for each of 8 wind directions for 42 years of record from the National Climatic Center, Asheville, North Carolina. The 336 resulting values corrected to hourly mean at gradient level, were ordered from highest to lowest and assigned probabilities of

$$P_i = \frac{i}{N + 1}$$

where i is the order number of the sample and N = 367,920, the total number of hours in the 42 year record. By using only the 95 largest values, the resulting velocity/probability combinations should reasonably represent the low probability events. The data plotted in Figure A.1 show that the fastest-mile data form a continuous curve with the hourly data. Since fastest-mile data was only available at 8 wind directions, the values at intermediate directions were interpolated.

The probabilistic model fit to the data and shown on Figure 7 was, for each wind direction, a Weibull

$$P(>U) = Ae - \left[\frac{u}{c}\right]^k$$

where A, c and k are constants. The value of A represents the fraction of time the wind blows from each of the 16 directions considered and was obtained from the published distribution of hourly data. The sum of A's from all wind directions was required to equal 1.0, a necessary condition for a consistent probability definition. The values of c and k were obtained by least squares fit.

Examination of Figure A.1 shows that the data points do not follow precisely a straight line, but have a definite curvature. A similar curvature in data in the Netherlands has been identified by Rijkoort [A2] to be due to atmospheric stability.

Because of the significant stability effects noted in the data, it is more accurate to use the surface wind data (22 feet) for pedestrian winds than to use gradient level winds. For the pedestrian wind analysis, the basic data was used with linear interpolation between data points, rather than the analytical fit to be sure that all characteristics of probability distribution were properly included. This data appears in Table A.1. The translation of the data to gradient level did not distort the probability distribution since the translation used the same neutral boundary layer characteristics which were used in the wind-tunnel model.

REFERENCES

A1. Hollister, S.C., "The Engineering Interpretation of Weather Bureau Records for Wind Loading on Structures," Building Science Series 30-Wind Loads on Buildings and Structures, National Bureau of Standards, 1970, pp. 151-164.

A2. Rijkoort, P.J., "A Compound Weibull Model for Description of Surface Wind Velocity Distributions," Scientific Report W.R. 83-13, Koninklijk Nederlands Meteorlogisch Instituut, 1983.

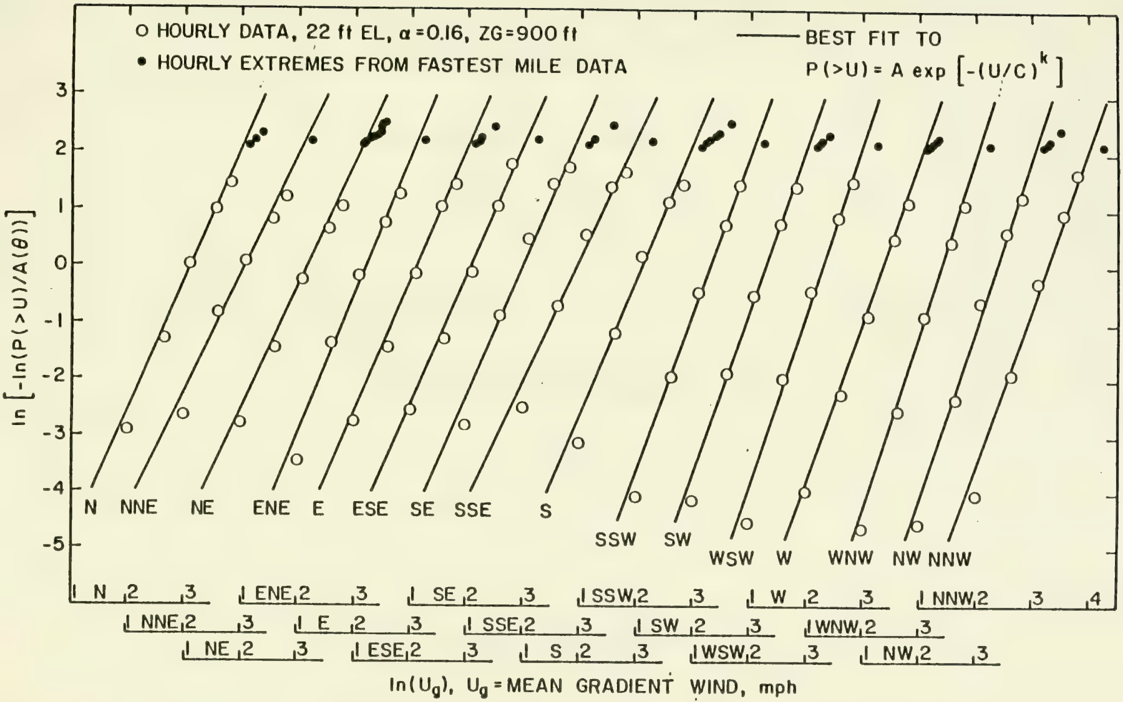


Figure A1. Wind Speeds in Boston by Direction

Table A.1

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED

Boston, Massachusetts

General Logan International Airport 1965-1974

Season : Annual

No. of Obvs. = 29206 Ht. of Meas. = 22. ft.

Velocity Levels in MPH

ZIMUTH	0- 3	4- 7	8-12	13-18	19-24	25-31	32-38	39-46	47+	TOTAL
N	.30	1.40	3.00	2.20	.40	.10	.04	0.00	0.00	7.44
NNE	.20	.80	.90	.70	.20	.10	0.00	0.00	0.00	2.90
NE	.20	.50	1.10	1.00	.30	.20	0.00	0.00	0.00	3.30
ENE	.10	.70	1.20	1.10	.30	.10	0.00	0.00	0.00	3.50
E	.30	1.00	2.40	2.30	.30	.10	.02	0.00	0.00	6.42
ESE	.30	.90	1.90	1.90	.30	0.00	.02	0.00	0.00	5.32
SE	.20	1.00	1.60	.60	0.00	0.00	0.00	0.00	0.00	3.40
SSE	.20	.80	1.10	.40	0.00	0.00	0.00	0.00	0.00	2.50
S	.30	1.60	3.00	1.80	.20	.10	.02	0.00	0.00	7.02
SSW	.10	.70	2.00	2.40	.60	.10	0.00	0.00	0.00	5.90
SW	.10	.80	1.90	2.70	.60	.10	0.00	0.00	0.00	6.20
WSW	.10	1.10	3.30	3.90	.70	.10	.04	0.00	0.00	9.24
W	.20	.90	2.70	5.00	1.50	.50	.10	.05	0.00	10.95
WNW	.10	.70	2.70	4.70	1.60	.50	.10	.05	0.00	10.45
NW	.10	.80	3.10	4.10	1.10	.30	.06	0.00	0.00	9.56
NNW	.10	.70	2.20	2.20	.40	0.00	0.00	0.00	0.00	5.60
CALM	.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.30
TOT	3.30	14.30	34.20	36.90	8.50	2.30	.40	.10	0.00	100.00

SHADOWS

SHADOW IMPACT ANALYSIS

The shadow analysis that was performed for the area surrounding the Parcel 7 Project included 22 individual readings that were taken at various times of the day during specific days of the year according to BRA requirements. The studies were conducted between the hours of 9:00 A.M. and 3:00 P.M., during the months of March, June, September, October, November and December.

The following data lists the exact time and dates for which the shadow readings were performed.

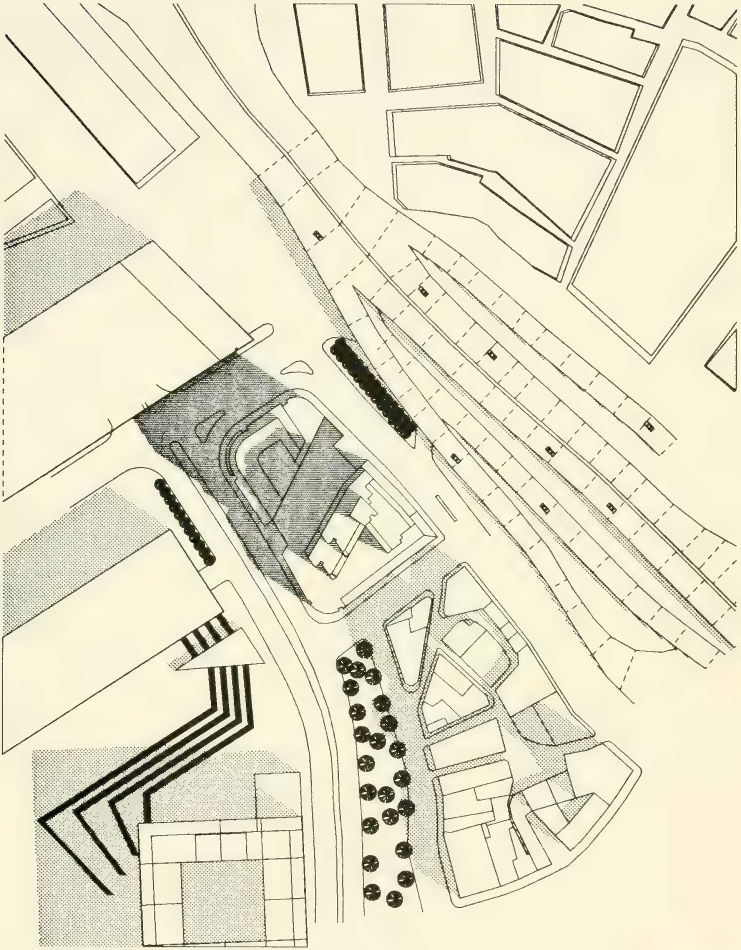
> October 21st and November 21st readings were taken at 10:00 A.M., 11:00 A.M., 12:00 P.M., 1:00 P.M., and 2:00 P.M.
>
> On the 21st day of March, June, September and December readings were taken at 9:00 A.M., 12:00 P.M. and 3:00 P.M.

The study showed no serious shadow impact on the surrounding neighborhoods. There was a slight impact on the MBTA Bus Station. This was indicated during the October, November and December analysis. The Parcel 7 shadow precedes the Parking Garage's own morning shadow across the Bus Station Zone. The analyses indicate that by approximately 1:00 p.m., the Parcel 7 Project no longer contributes to the shading of the Bus Station.

There was also a slight impact to the Expressway and North End. However, only on December 31 at 3:00 P.M. did the analysis indicate a net shadow reaching the North End.

The Shadow analyses showed no impact on the Blackstone Block, which is situated to the south and southwest of Parcel 7, out of the shadow pattern altogether.

It can be concluded that the Parcel 7 Project net shadows impose no significant shadow impacts on the surrounding areas.



21 March 9:00 a.m.

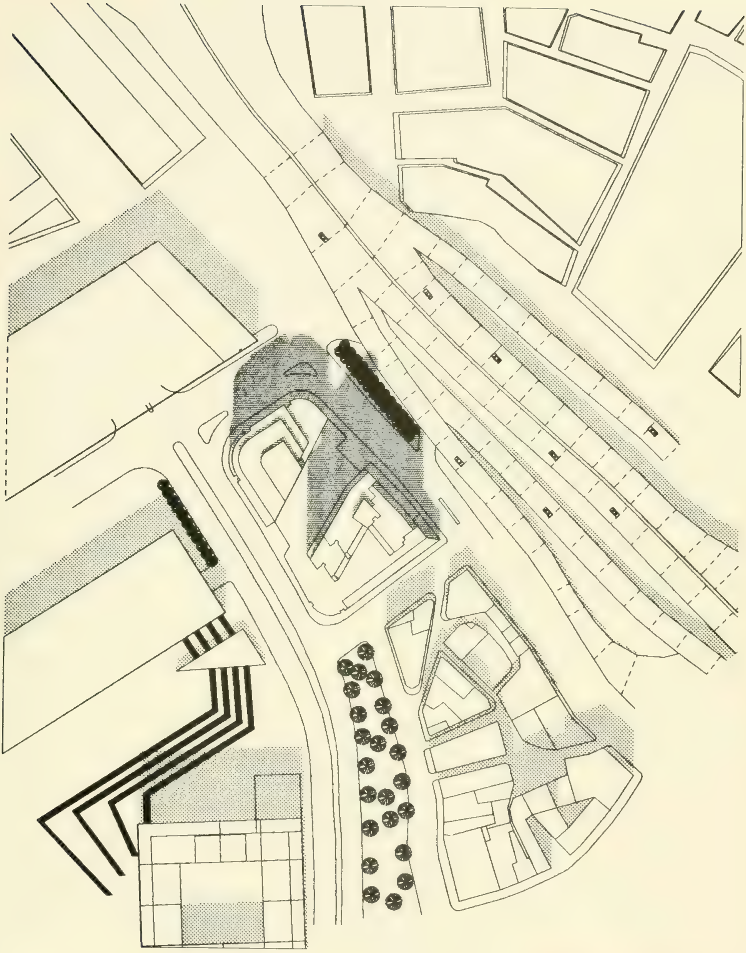
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986

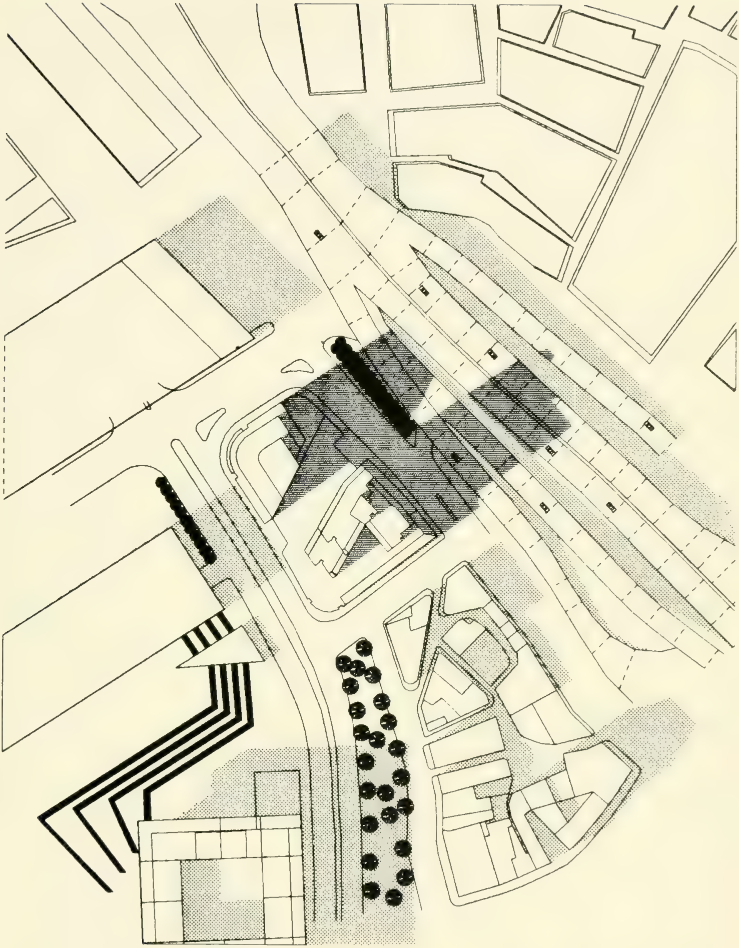


21 March 12:00 p.m.
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts
Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 March 3:00 p.m.

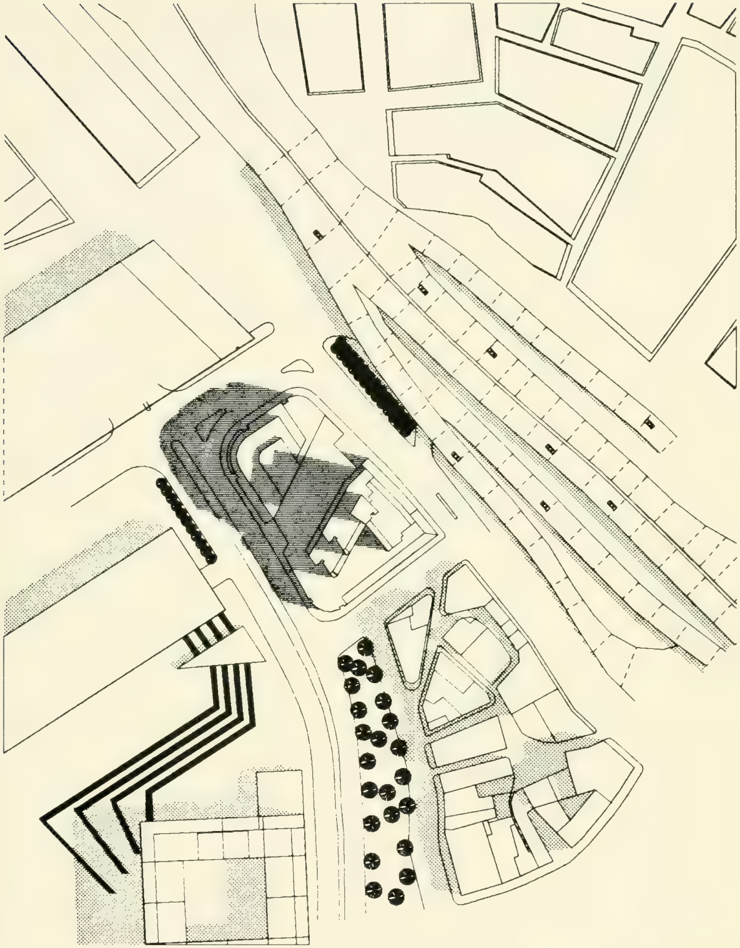
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 June 9:00 a.m.

SHADOW IMPACT ANALYSES

Key: ▆ Proposed
▨ Existing

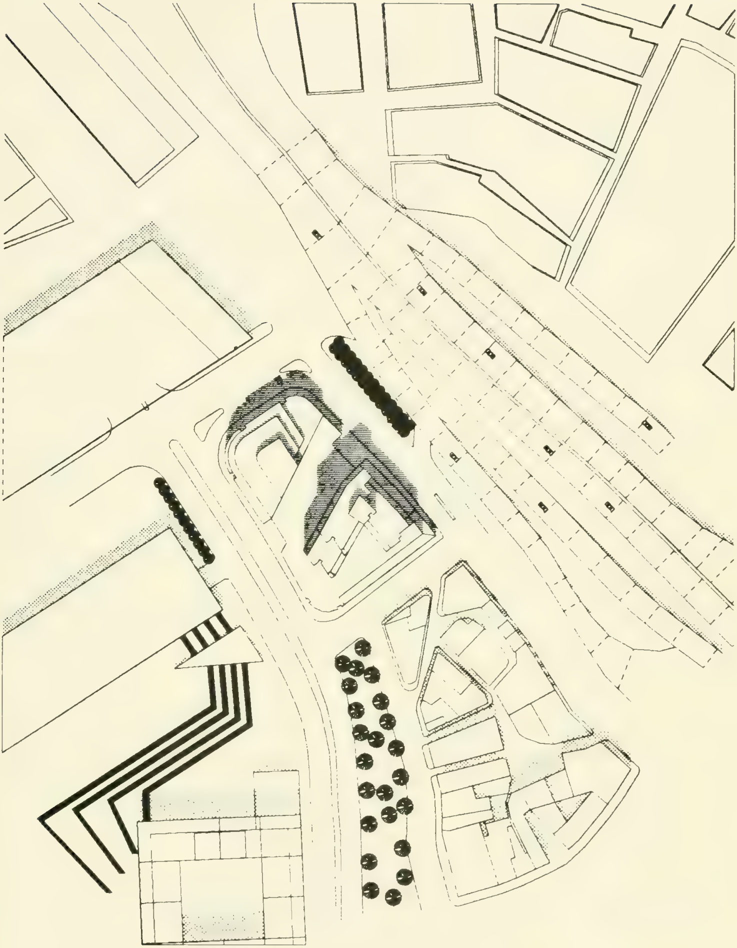
0 40 80 120
100 140

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 June 12:00 p.m.

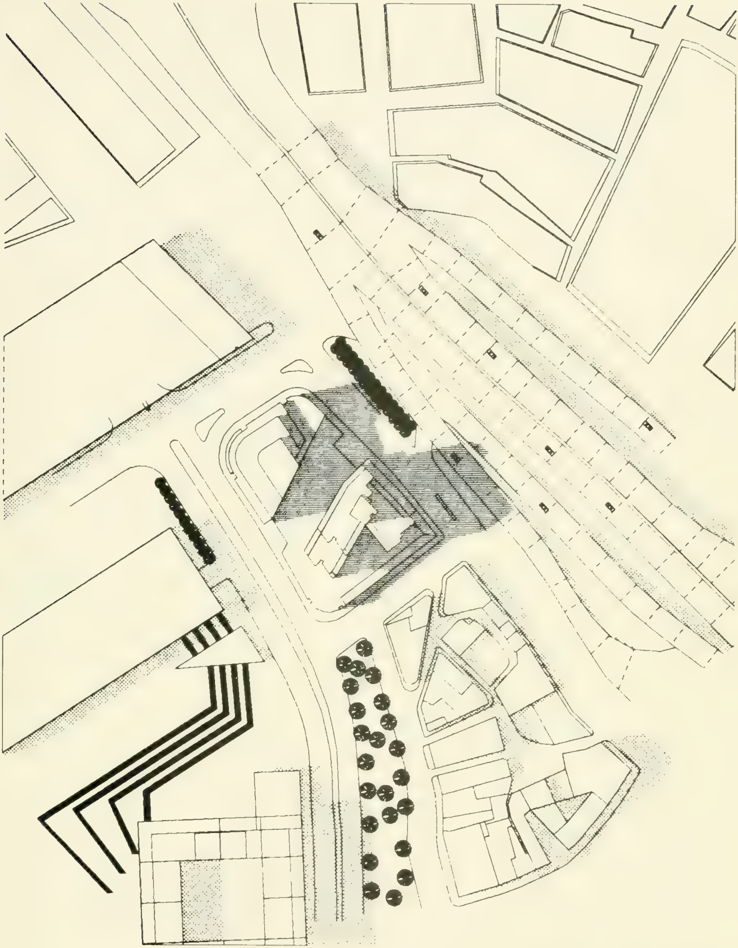
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 June 3:00 p.m.

SHADOW IMPACT ANALYSES

PARCEL 7

Boston, Massachusetts

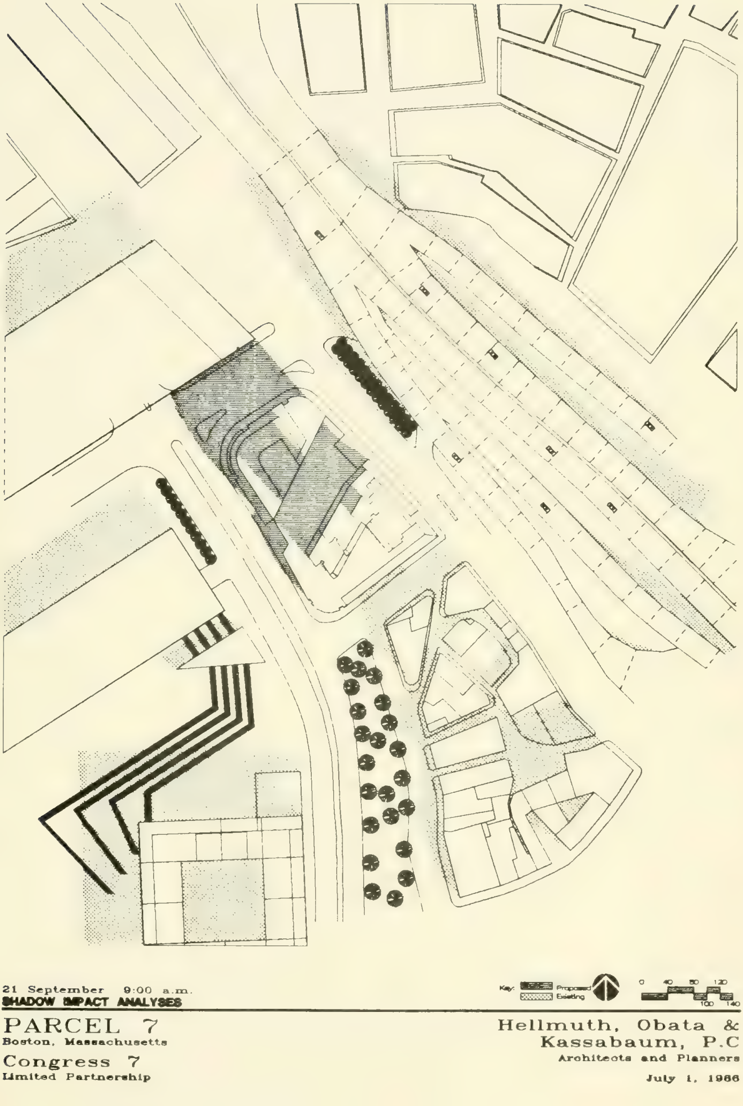
Congress 7

Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C

Architects and Planners

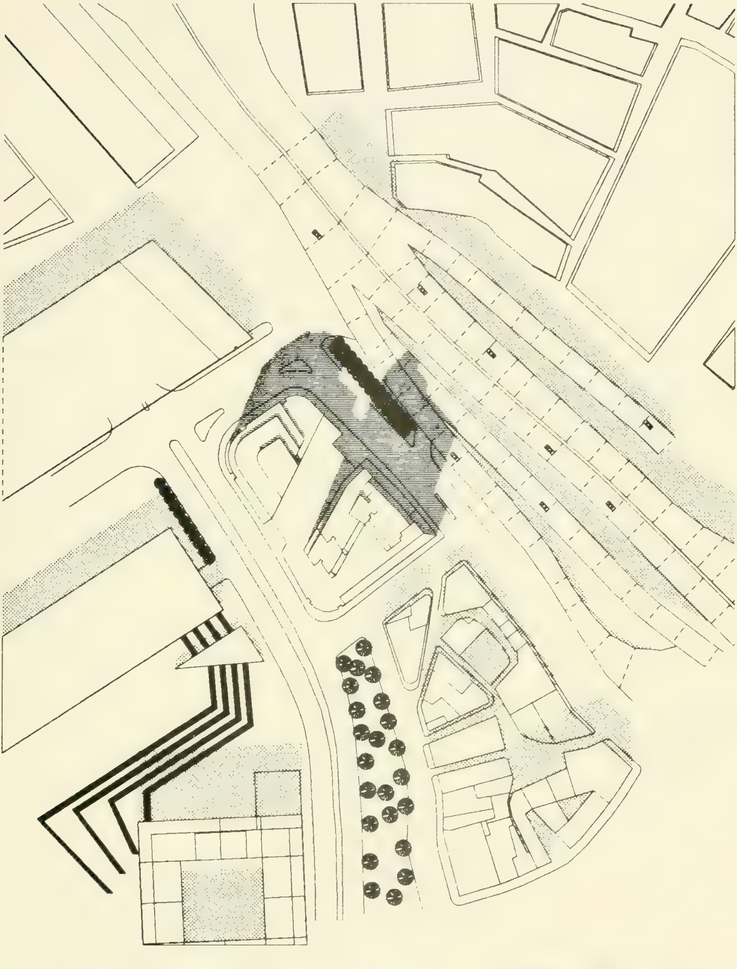
July 1, 1986



21 September 9:00 a.m.
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts
Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners
July 1, 1986



21 September 12:00 p.m.

SHADOW IMPACT ANALYSES

Key: ▬ Proposed

▨ Existing

PARCEL 7

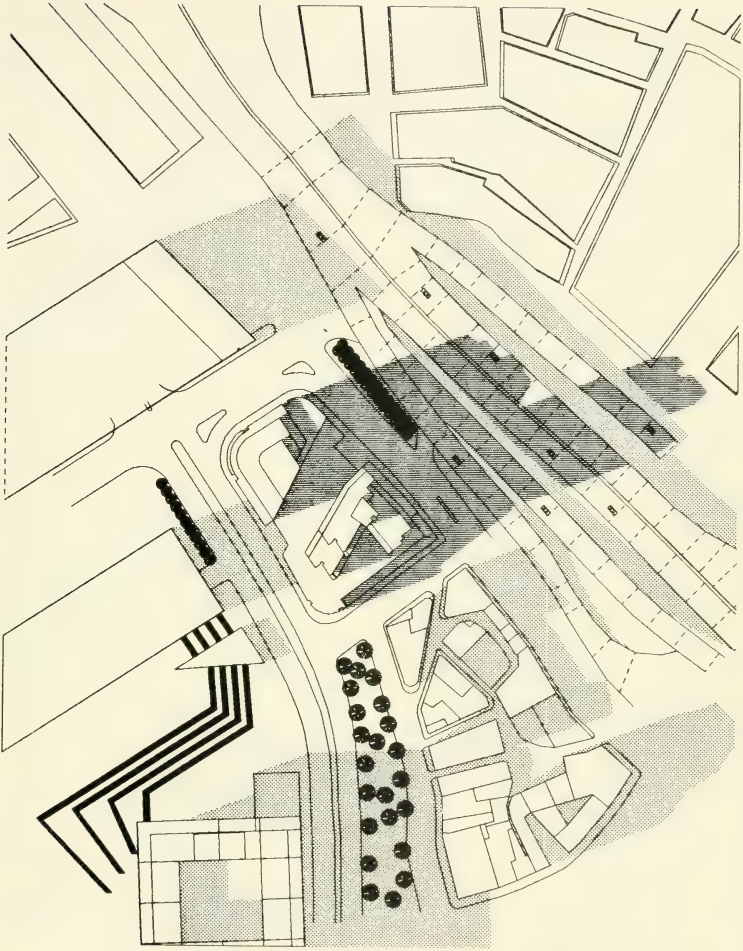
Boston, Massachusetts

Congress 7

Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 September 3:00 p.m.

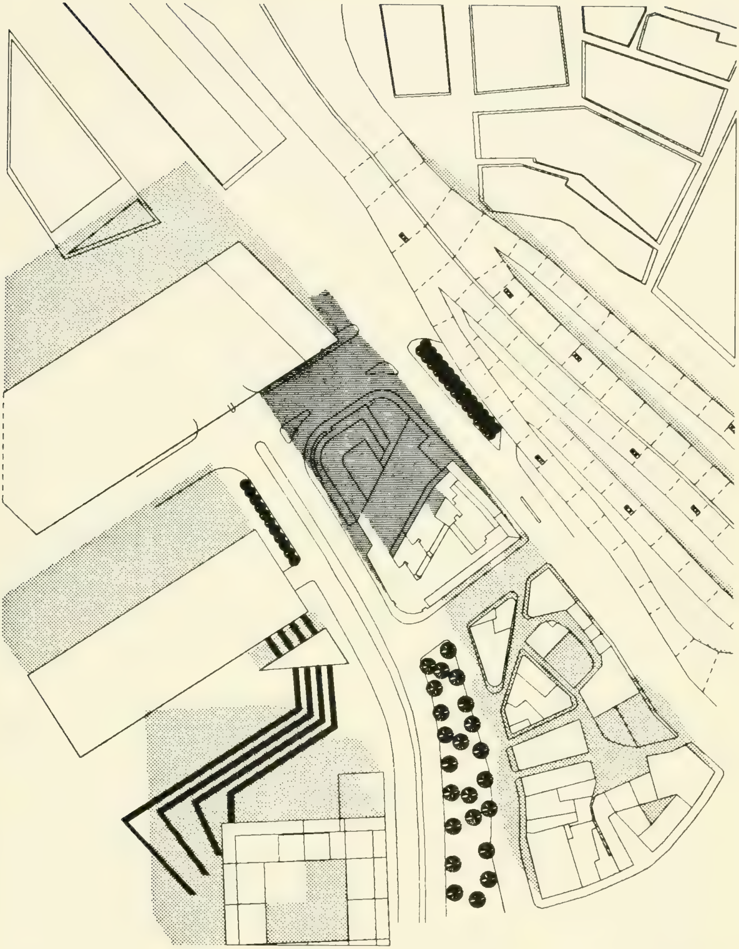
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 October 10:00 a.m.

SHADOW IMPACT ANALYSES

Key: ▨ Proposed

▒ Existing

PARCEL 7

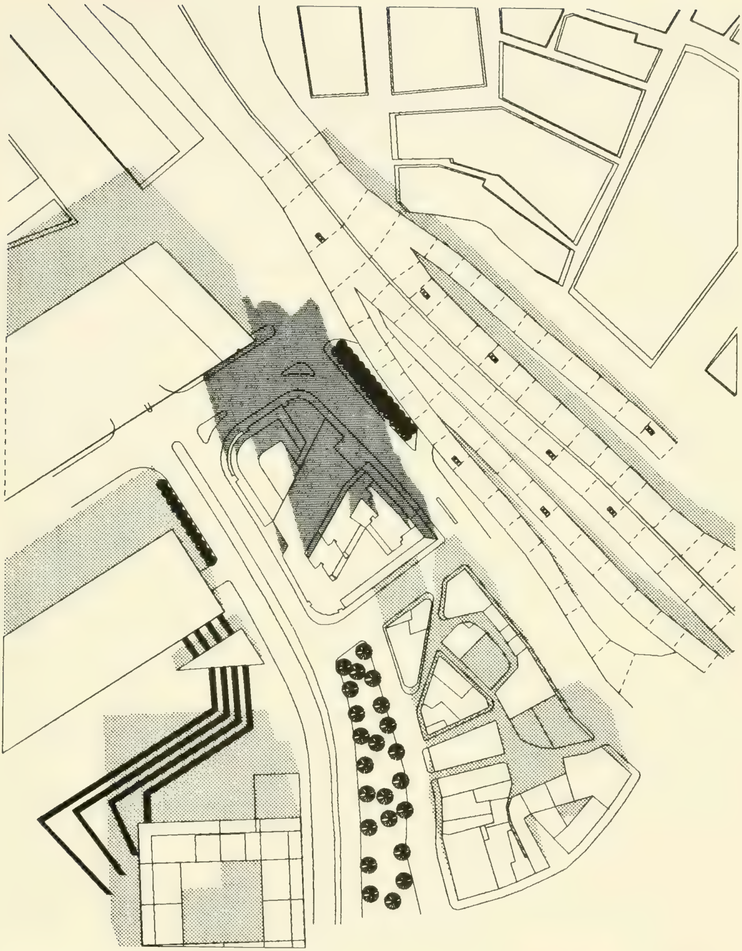
Boston, Massachusetts

Congress 7

Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 October 11:00 a.m.

SHADOW IMPACT ANALYSES

Key: ▨ Proposed
▒ Existing

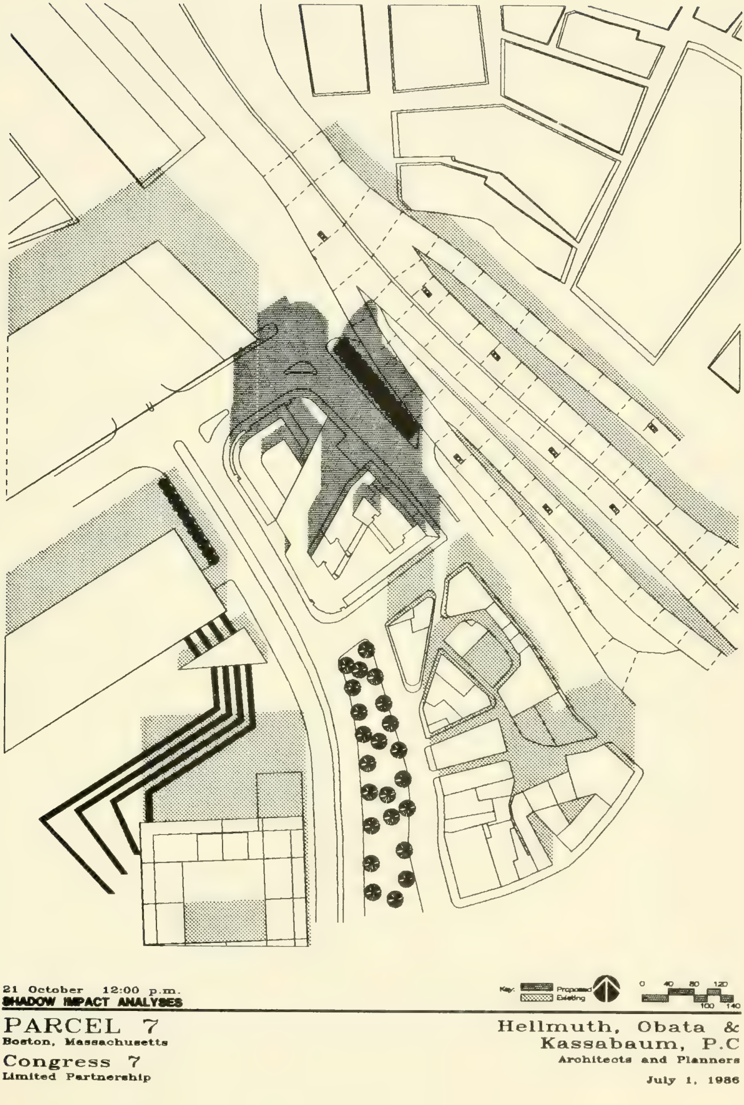
PARCEL 7

Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 October 12:00 p.m.

SHADOW IMPACT ANALYSES

Key: ▇ Proposed ▨ Existing

PARCEL 7

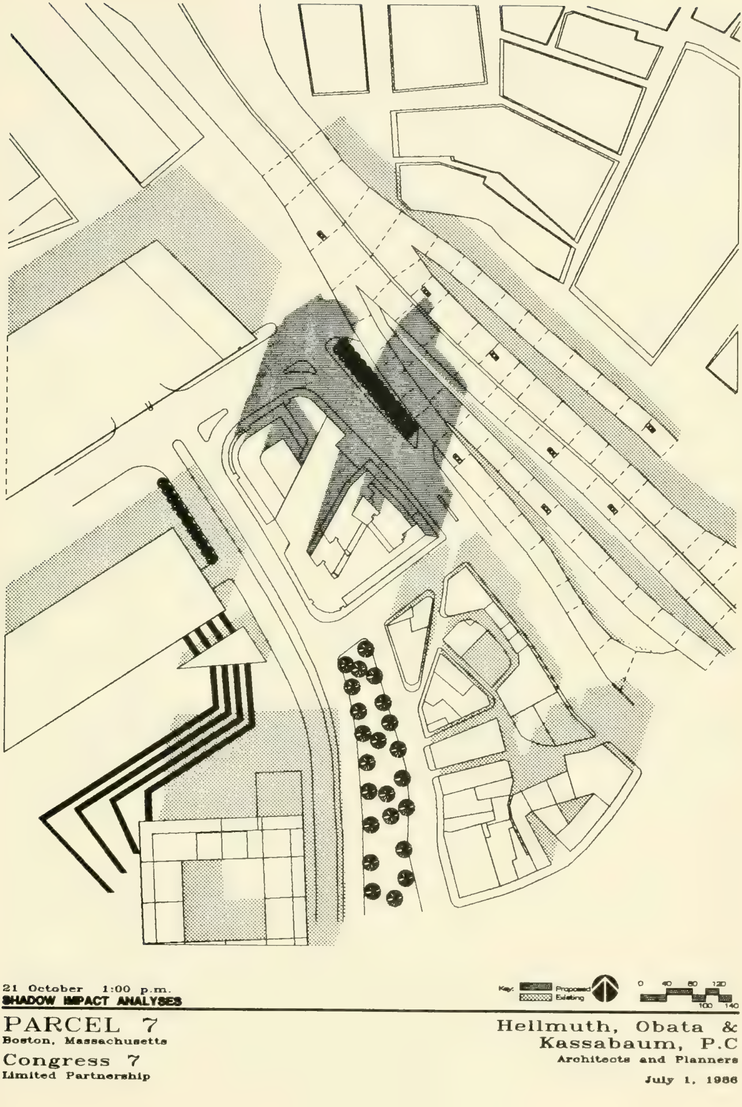
Boston, Massachusetts

Congress 7

Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 October 1:00 p.m.

SHADOW IMPACT ANALYSES

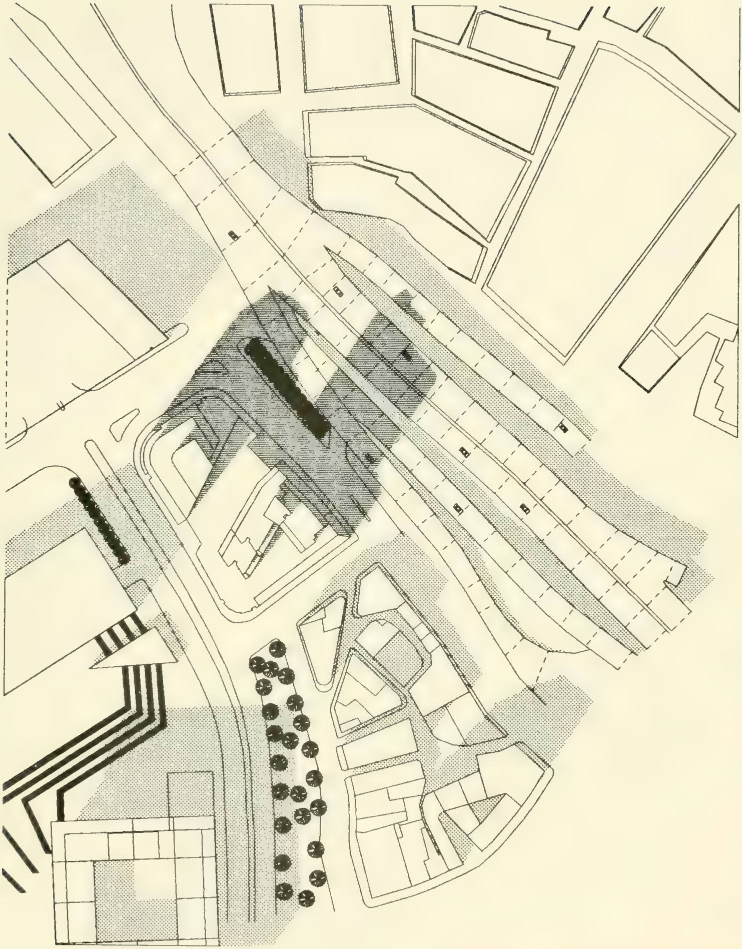
Key: ▇ Proposed ▒ Existing

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 October 2:00 p.m.

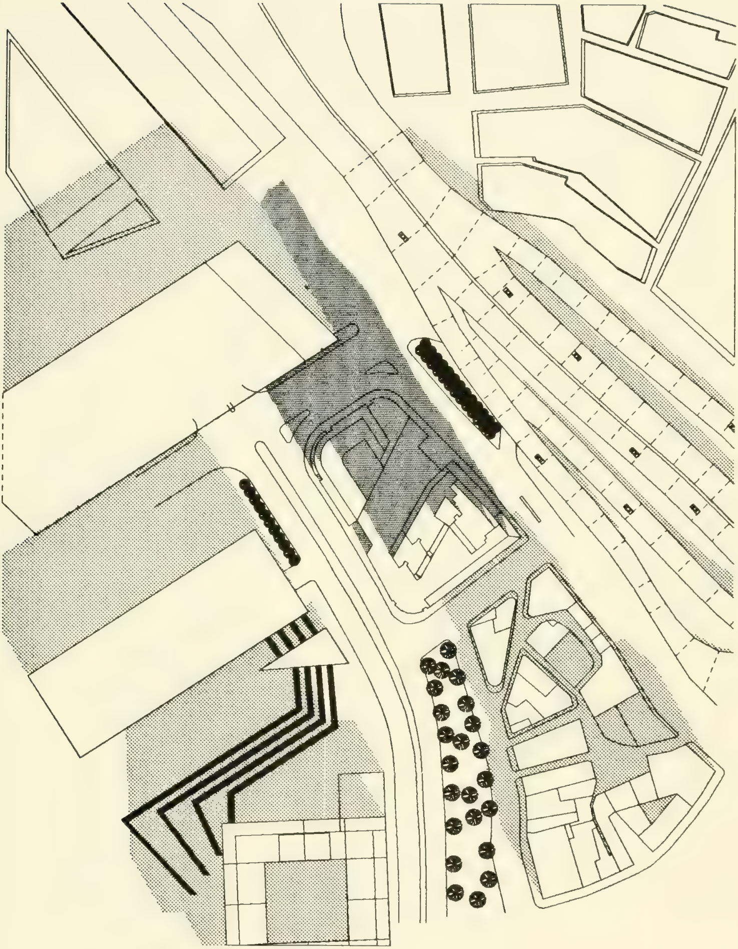
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 November 10:00 a.m.

SHADOW IMPACT ANALYSES

PARCEL 7

Boston, Massachusetts

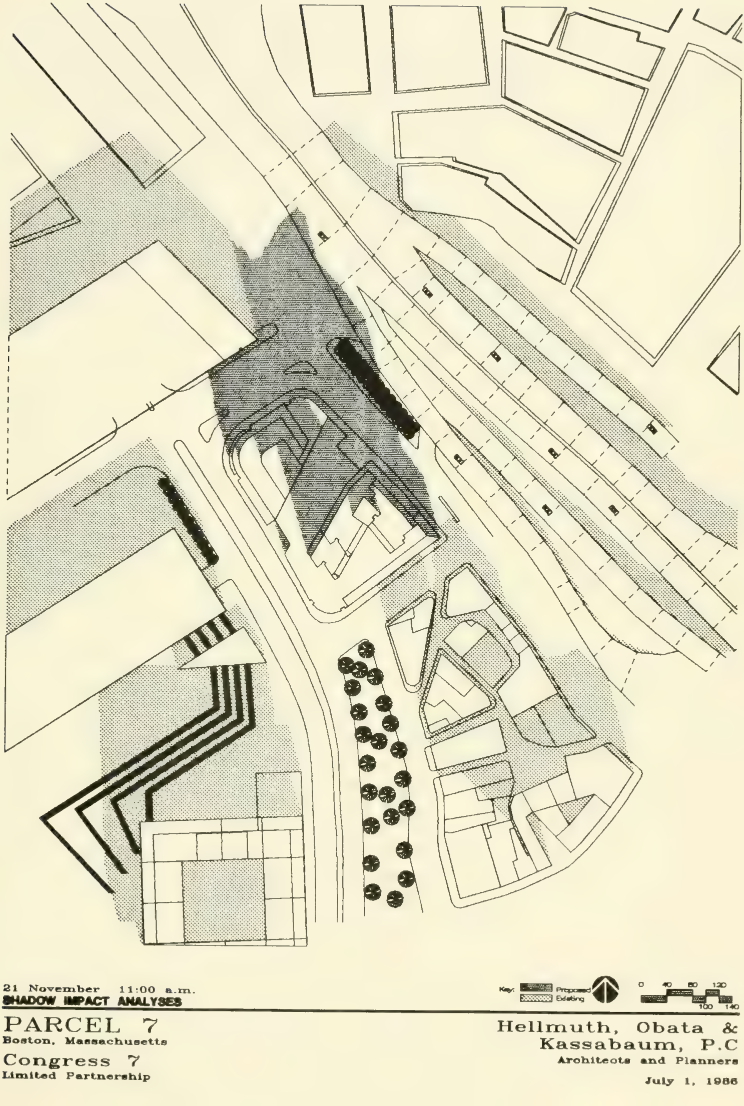
Congress 7

Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C

Architects and Planners

July 1, 1986



21 November 11:00 a.m.

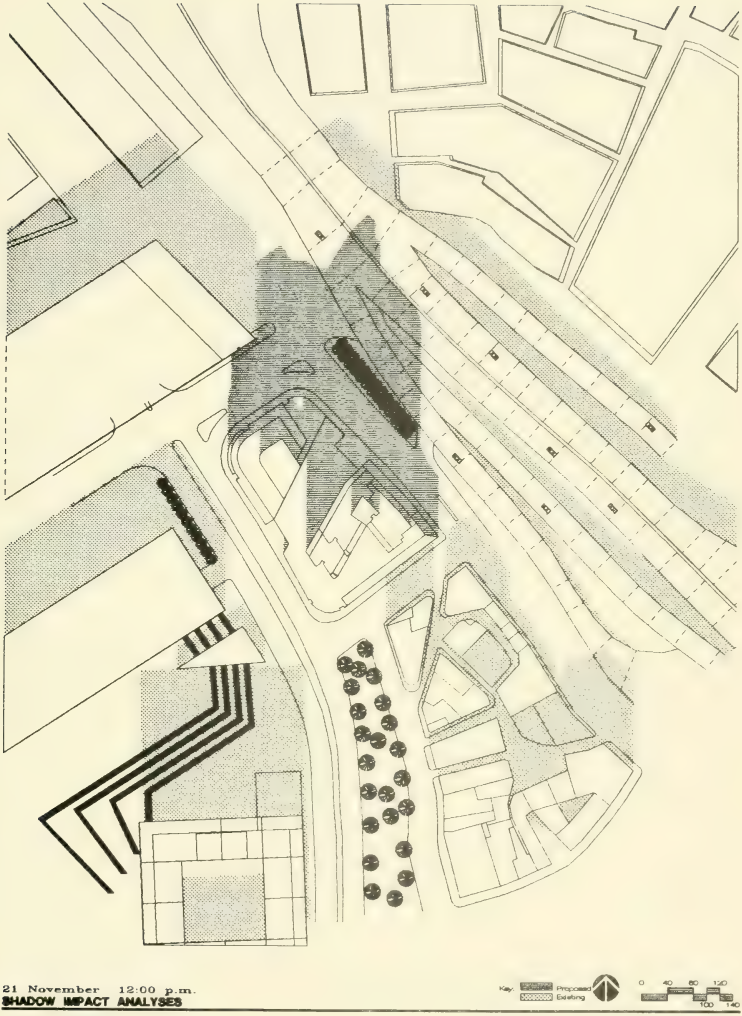
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 November 12:00 p.m.

SHADOW IMPACT ANALYSES

PARCEL 7

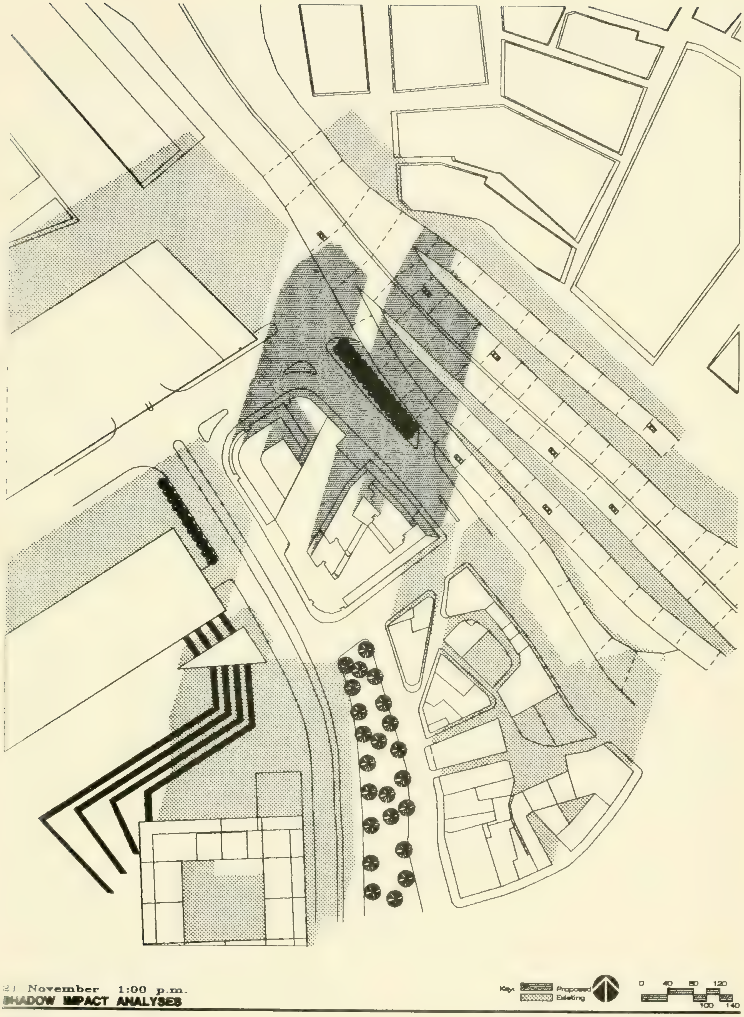
Boston, Massachusetts

Congress 7

Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 November 1:00 p.m.

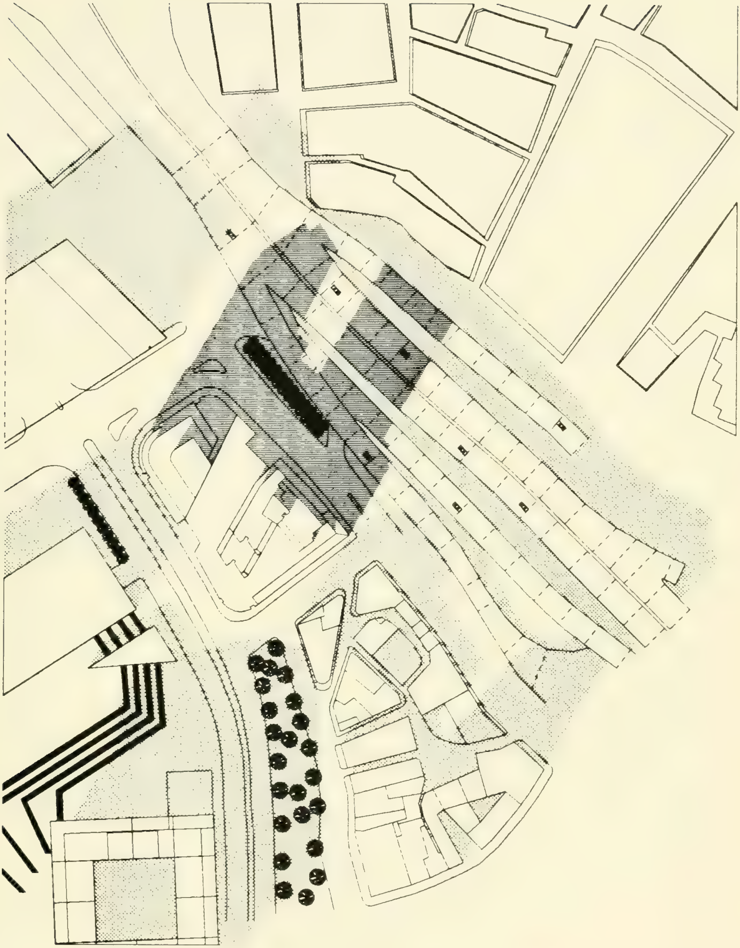
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 November 2:00 p.m.

SHADOW IMPACT ANALYSES

Key: ▨ Proposed

▒ Existing

0 40 80 120

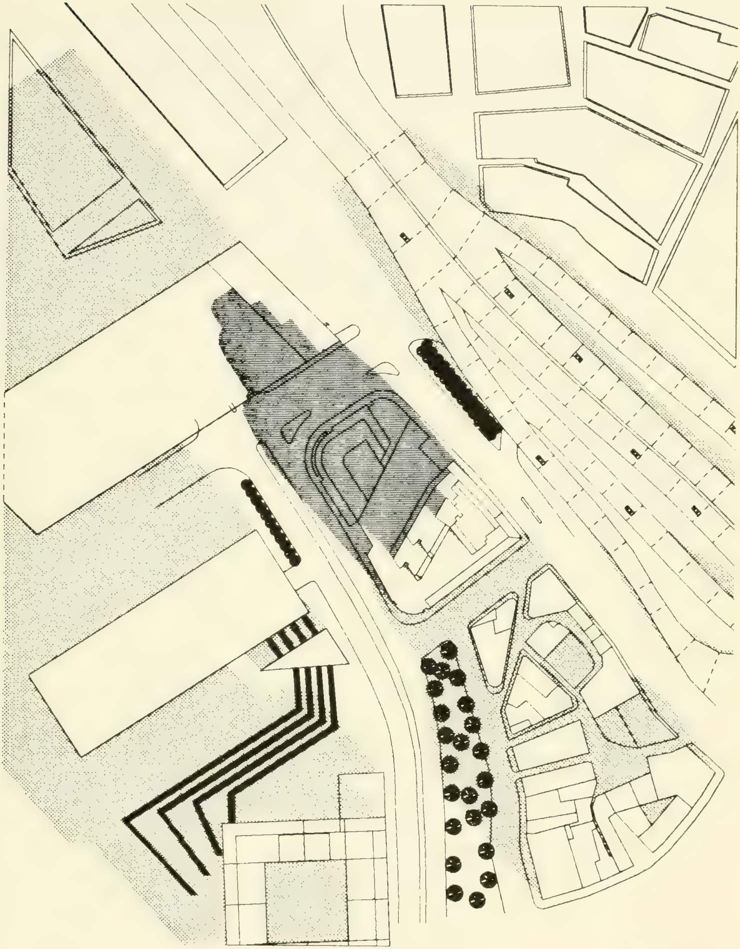
100 140

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 December 9:00 a.m.

SHADOW IMPACT ANALYSES

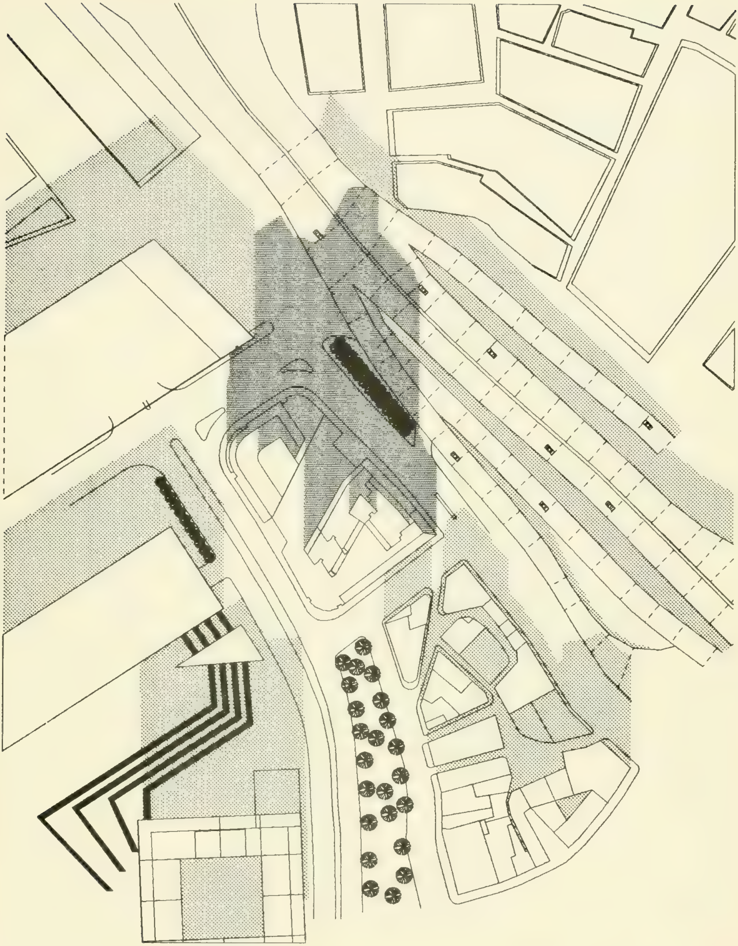
PARCEL 7

Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986



21 December 12:00 p.m.

SHADOW IMPACT ANALYSES

PARCEL 7

Boston, Massachusetts

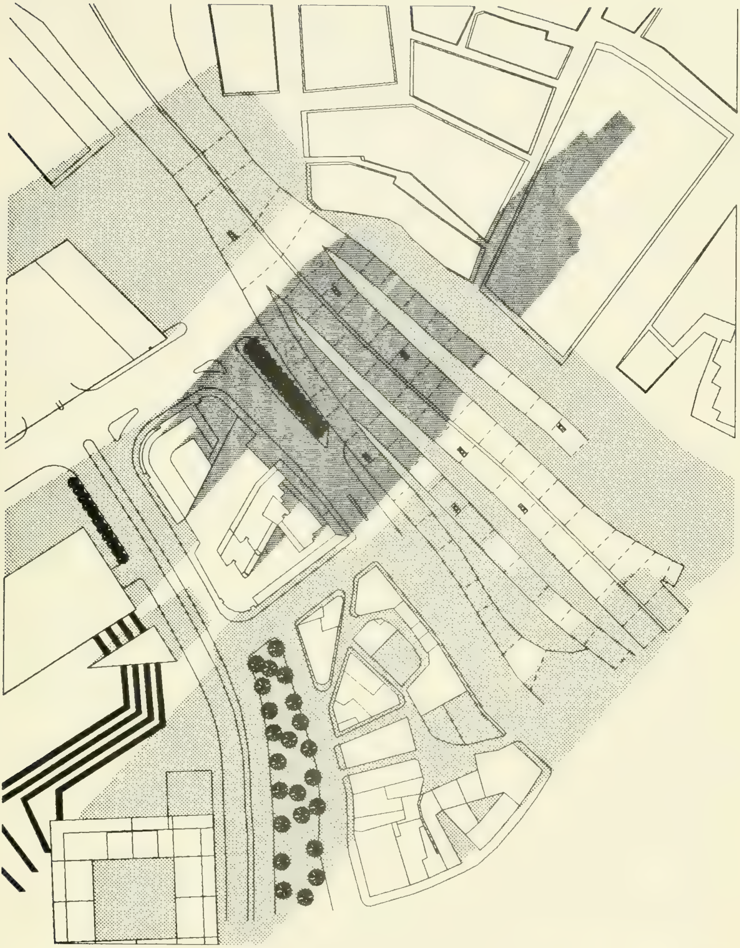
Congress 7

Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C

Architects and Planners

July 1, 1986



21 December 3:00 p.m.
SHADOW IMPACT ANALYSES

PARCEL 7
Boston, Massachusetts

Congress 7
Limited Partnership

Hellmuth, Obata &
Kassabaum, P.C
Architects and Planners

July 1, 1986

1235 23

BOSTON PUBLIC LIBRARY
3 9999 06315 449 4